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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institution of British Foundrymen.

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Papers for Manchester Conference.

The following Papers are expected to be submitted to the annual meeting, which is to take place from June 12 to 15:—(1) Exchange Paper from the American Foundrymen's Association, by Major R. A. Bull, of Chicago, Research Director of the Electric Steel Founders' Research Group; (2) Paper by Professor A. Campion and J. McEachan, entitled "Core Oils and Binders"; (3) Paper by Mr. F. A. Melmoth, entitled "The Manufacture of Steel Castings and the Preparation of Sand"; (4) Exchange Paper from the Association Technique de Fonderie, by Professor J. Seigle, of Nancy, entitled "Silicon-Carbon."

Present-Day Foundry Economics.

When a person starts on a long voyage he divides his baggage into "necessities" and "might be wanted." This second division, if he is wise, he keeps to the lowest possible limit in order to ensure easier passage through custom houses and to diminish freight charges. An experienced traveller, when debating whether to carry a certain article, will often decide that it is preferable to take a supply of money, so that if a "might be wanted" article becomes a "necessity" he purchases it *en route*.

Foundries are now entering upon a journey through a difficult economic period, and their owners might do worse than follow the experienced traveller's advice. For instance, there exists in every foundry yard a collection of foundry boxes and tackle which the observant foreman can easily divide into "necessities" and "might-be-wanteds." At the moment pig-iron is dear, due, according to generally accepted economic principles, to the fact that there is a great demand. Now, if the foundries of Great Britain will reduce their demands upon the pig-iron market by utilising this vast store of "might-be-wanted" tackle, and either using it themselves or putting it into the hands of those who can, they will probably gain a credit sufficient to pay for the conversion of a piece of "might-be-wanted" tackle into a "necessity" should the occasion arrive. Cast-iron scrap, to the intelligent modern foundry manager, is very much like beer was to the old-fashioned moulder—none is bad, only some is better than others. In the case of scrap, representative parcels should be put through the cupola, cast into pigs, and graded according to fracture or analysis, or preferably a combination of the two.

It would be interesting to know what value the foundries place upon the large masses of scrap, which are extremely difficult of breaking to sizes suitable for cupola-melting. Propeller bosses are typical of this. We suggest that present economic conditions permit in a large number of cases the construction of special furnaces, in which the charge is introduced into the hearth by means of a removable roof. Such a plant need not be expensive, and if any quantity exists a distinct economy can be shown if such remelted material can reduce the demand upon the market.

Is there any means of reducing the demand upon the coke market? Oil-fired cupolas suggest themselves, but no plant has really passed the experimental stage, and considerable capital outlay must be made before the process can be established. On auxiliary oil firing, considerable technical data is available. It should be remembered that, many years ago, coal was used in the cupola, and this suggests a useful method of easing the coke demand. We do not suggest that coke should be replaced by suitable coal, but only diluted, the extent of which would vary in every foundry.

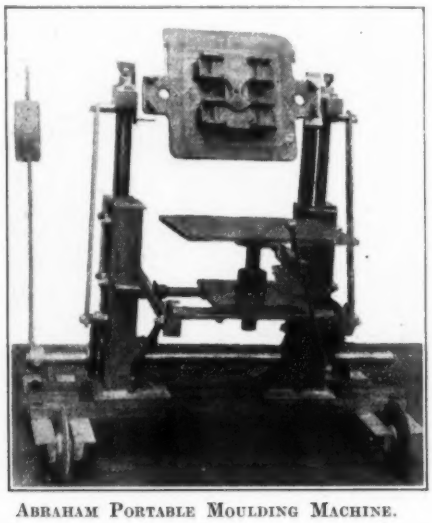
The hypothetical conditions outlined may not apply in some foundries, but there do exist in many foundries conditions which call for a close examination of the "might-be-wanted" tackle which could easily be liquified and liquidated.

Institute of Metals.

Dr. W. Rosenhain, F.R.S., of the National Physical Laboratory, is to deliver the May Lecture on May 2, at 8 p.m., at the Institution of Mechanical Engineers, Storeys Gate, S.W.1. His subject will be "The Inner Structure of Metals."

The "Abraham" Portable Moulding Machine.

With moulding machines generally, it is essential that the surfaces of the boxes shall be absolutely even; otherwise it is impossible to get a clean draw. In the machine illustrated the table is pivotally mounted in such a manner that it instantly adapts itself to boxes with uneven surfaces. This is accomplished by securing the table to a stud attached to a vertically-adjustable pillar by means of a ball joint and locking plates. The table is mounted upon runners and arranged to draw out. The pattern is carried by a reversible



Abraham Portable Moulding Machine.

plate, pivotally mounted on the columns running between rollers and operated through a link and crank by the balanced lever. It will be noted that the supporting columns are adjustable laterally, an arrangement which permits the machine to take boxes from 8 in. up to 18 in. in width. The height of the draw is also adjustable from 1 in. up to 6 in. The whole machine is of liberal design, rigid and strong, and the use of small parts usually subjected to heavy wear has been eliminated in the construction. The complete machine is mounted upon four wheels, and is readily portable. The machine is being manufactured by The Wallwin Company, Saltisford Ironworks, Warwick.

Foundry Queries.

C. I. Mixture for Superheated Steam.

I am anxious to ascertain what should be the properties of cast iron to resist the constant high temperature of superheated steam, and yet be suitable, from machining and wearing standpoint, for a cylinder liner. Secondly, what quality pig and the various other ingredient should be fed into the cupola, and what air pressure should be used for the blow to produce the necessary final content.

If you can furnish me with the foregoing I shall be greatly obliged, if not perhaps one of your regular readers would be willing to offer suggestions.—A. H.

An American Blast-Furnace Record.—A report from Youngstown, U.S.A., states that in March the blast-furnace of the Trumbull-Cliffs Furnace Company, at Warren, established a production record for that plant in turning out 24,758 tons of pig-iron. Its daily average was 798.6 tons, comparing with a February daily average of 776 tons. On one day in March the stack produced 1,011 tons of iron. This furnace was designed and erected by Messrs. Freyn, Brassert & Company, 38, Victoria Street, Westminster, S.W.1, and 122, Michigan Avenue, Chicago.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Dearth of Foundry Metallurgical Chemists.

To the Editor of The Foundry Trade Journal.

Sir,—With reference to Mr. W. T. Evans' remark during his valedictory address to the East Midland Branch of the I.B.F.; reported in your issue of April 19 as to the scarcity of chemists with practical foundry experience. This will cause surprise to many metallurgical chemists, who have made a study of the foundry at one time or other but have had to turn their attention to other industries, through lack of openings in the foundry trade. I know personally several chemists who have had years of experience both in the laboratory and in the foundry who have had to take up work in other lines. The writer himself has had many years' experience in laboratories and in metallurgical and engineering works, including practical cupola work; and as a statement of scarcity implies a known demand, would be glad if Mr. Evans would indicate the firm or firms that have felt this want. Several years ago a similar statement was made at a foundrymen's meeting with no more truth than at the present day. There can be no real demand while only a minority of the foundrymen have any interest in scientific control or belief in its efficacy in lowering the percentage of wasters. Such statements only cause chemists to spend thought on the foundry which could more profitably be spent in other directions.

Yours, etc.,

"Metallurgical Chemist."

[We interpret Mr. Evans' meaning to be that there is a scarcity of chemists possessing attributes other than professional ones, such as a keen appreciation of the foundryman's mentality. —Ed.]

Separation of Charges in the Cupola.

To the Editor of The Foundry Trade Journal.

Sir,—In reply to the leader, "Proof Wanted," I submit the following experience: I often charge five or six different mixes of iron during one blow; I take a fracture test from each charge. These, of course, are not broken till the following morning, when they invariably conform to what is expected, and when transverse tests are taken (locally), they vary in proportion to the mix charged. The tests vary between 2,569 lbs. and 3,906 lbs. Tensile tests taken at Sheffield from four separate charges gave the following results:—13.0; 13.2; 14.4 and 15.2 tons per sq. in.

I should be interested to hear what other foundrymen are doing in this direction. The cupola used is 33 in. dia., driven by a Keith-Blackman blower at a pressure of 11 ozs. The maximum melt is 3.5 tons per hour.

Yours, etc.,

Henry Wheatley.

9, Granville Road,
Colchester.

[No proof of absolute separation is shown here. —Ed.]

Institution of British Foundrymen.

Newcastle Branch.

The Junior Section held their third general meeting on April 21, when Mr. S. D. Blenkinsop (Junior Vice-President) read a Paper entitled "Methods of Steel Manufacture."

The lecturer described the Bessemer, open hearth and electric processes. He dealt with the refining of steel and also described the acid and basic practice.

After the address there was an excellent discussion in which Messrs. Van-der-Ben, Liddell, Chapman, Boudry, Flynn, Nicholson, Little, Jay, Clements and Grey took part.

The membership of the Junior Section has now increased to 55.

Notes on Malleable Iron Production.*

By W. H. Poole, M.I.Brit.F.

(*Continued from page* 311.)

By keeping the sulphur low and the corresponding lower annealing temperature, phosphorus may be present up to 0.25 per cent. without any appreciable harm being done. It would appear that in the pig-iron to be employed either sulphur or phosphorus may be present, but not both.

How Manganese Acts.

This element tends to keep the Fe_3C in solution similarly to sulphur. A small amount up to 0.3 per cent., according to Hague and Turner,

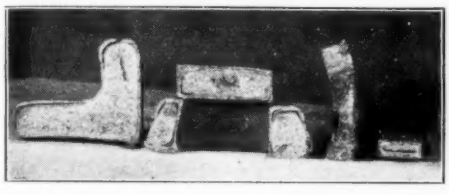


Fig. 5 showing fractures exhibiting peeling action.

tends to help the silicon to throw out the graphite. The reason for this has not been fully investigated yet. In iron it is usually found (1) Combined with Carbon as Mn_3C, (2) Combined with S forming MnS, (3) with low Mn, excess sulphur is as FeS.

It has been put forward by Sauveur, that when carbon is combined with the manganese, forming Mn_3C, it cannot be so easily thrown out of com-

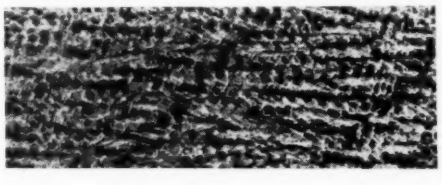


Fig. 6.—Shows a white iron as cast, containing 3.12 per cent. total carbon, all combined.

bination by the various agents. Hence a high manganese content tends to resist the formation of graphite.

Annealing Malleable.

For this purpose special annealing ovens are used, so designed that a temperature condition necessary for malleablising is obtained. The many

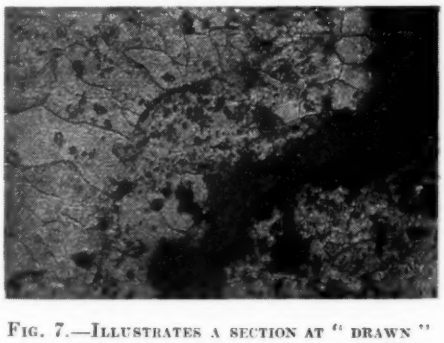


Fig. 7.—Illustrates a section at "drawn" spot in annealing casting. Note the ferrite crystals.

designs will not be detailed, but the following types are examples: (1) Beehive type worked with semi-producer plant; (2) direct coal-fired ovens; (3) direct-fired case ovens; and (4) specially designed regenerative-type-oven.

Much profitable time could be spent in the discussion of this point, but it will be assumed there is a plant capable of giving the temperature conditions necessary. The white-iron castings are packed in pots, hematite ore being the medium. Various strengths of new and spent ore are used, the heavier work requiring a stronger mix. The pots are stacked in the furnace, the door luted up, and firing commenced.

Process Employed.

This process merely modifies the form of the carbon present, leaving the other elements the same. Successful results can only be obtained by paying attention to the following factors: (1) Composition of the "white" casting; (2) correct temperature range—furnace control; (3) time given at this temperature; (4) rate of cooling; (5) packing details; and (6) human element.

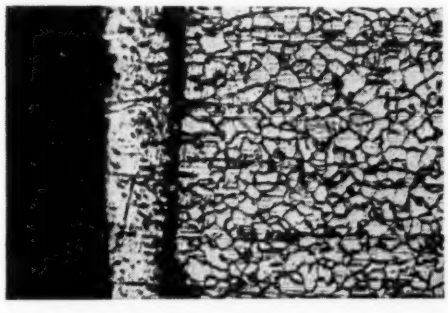


Fig. 8.—Is the edge of an annealed sample, showing commencement of skin-peeling action. Very fine ferrite structure. It has been made from pot-melted malleable.

The first two factors are dependent upon one another, that is, the correct temperature range can only be determined by studying the composition in the light of the various effects of the elements. For example, the vast difference between American "Black heart" and European "White heart" annealing temperatures can be taken as the effect of the different proportions of sulphur in the two processes. With regard to

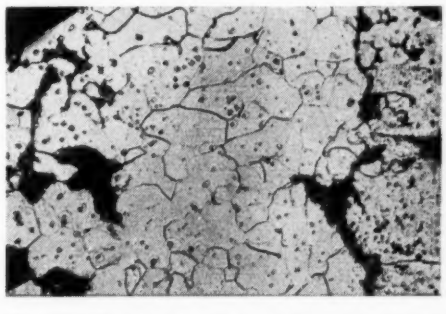


Fig. 9.—Is taken from near the edge of an annealed sample, showing skin oxidation and manganese sulphide inclusions. There is some pearlite structure showing.

factor 3, it is necessary to break down entirely the "white" structure, as it will otherwise prevent the maximum toughness being obtained. One feature of not quite breaking down this white structure is to keep up the tensile strength, but this is done at the expense of toughness and ductility.

The rate of cooling is an important feature, because this must take place very slowly through the critical range about 700 deg. C., otherwise

* A Paper presented to the London Branch of the Institute of British Foundrymen.

some of the carbon may go into solution again, producing hardness and brittleness. Below 680 deg. C. cooling may be more rapid.

It is possible to anneal without any packing material, though there are advantages in its use which far outweigh its cost and extra labour. For instance, (1) Proper packing practically eliminates any warping; (2) the oxide of iron used in Reaumur process assists oxidation and expedites annealing; and (3) it is necessary to obtain good-quality hematite and free from fusible portions which would lead to scabbing of the surface.

The last factor mentioned, namely, the human element, comes into play in all kinds of work and is known under various names, such as "knack," "experience," etc. This agent is ever-present. Suffice it to say that it is the combination of the man, the furnace, and the casting which governs the final result, and not one or any two of them.

Though these remarks are brief, the vital importance of the annealing operation can be seen. It is here that accurate means of temperature checking with pyrometers, etc., can be utilised.

Careful judgment is necessary in packing, in judging the hot or cold spots in the oven, and in many small points gained by experience in any plant.

Defects in Malleable Iron.

A study of the likely defects in malleable-iron work is at the same time both fearful and wonderful. In the white-iron castings, for example, special feeding heads must be made to allow for

FIG. 10.—IS TAKEN AT THE JUNCTION OF FERRITE EDGE AND HIGHER-CARBON CORE IN ANNEALED MALLEABLE. FINELY-DIVIDED AMORPHOUS CARBON TO BE NOTED IN CORE.

the high shrinkage of the metal, which is approximately 0.25 in. to the foot. Lack of feeding results quickly in drawn castings.

Cracking troubles are frequent in the white castings, when either the mould or metal condition is abnormal. Chills are often used to counteract these troubles. After these worries the annealing process is to be combated. Warping, cracking, peeling, pitting, burning are a few defects.

Warping.—In packing, special care and thought are necessary.

Cracking.—A source of trouble in this respect is rushing up the furnace to heat too quickly. Castings strains, which are sometimes released on heating and poor design are other contributory factors

Pitting.

The various causes suspected are high temperature, strong ore, or impurities in the ore, such as silicates, sulphides, etc. Examination of the ore

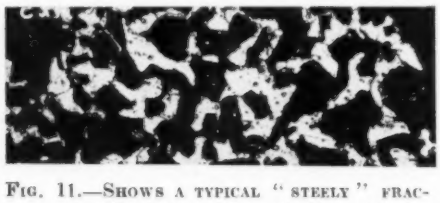


FIG. 11.—SHOWS A TYPICAL "STEELY" FRACTURE SHOWN IN ANNEALED MALLEABLE IRON. THIS IS VERY DUCTILE METAL.

and actual experiments, incorporating in test pans all manner of impurities in admixture with the ore, elicited the following:—

(1) That pitting will result at a high or low temperature of annealing if there is present in the ore an appreciable quantity of oxide or carbonate of manganese.

(2) That lime compounds such as sulphate or sulphide or silicate are liable to cause a deep form of pitting, but only at high temperatures.

(3) In some cases fusible silicates have been known to form pits, but the above causes are far more common.

Pitting, then, is best avoided by a proper selection of ore, particularly with regard to the manganese-content, which should on no account exceed 1.0 per cent. of MnO. Fortunately in many ores it is as low as 0.3 per cent. The author has found this constituent to be present in red hematite ore, usually in the form of veins or small particles of the dark brown dioxide (MnO_2), though sometimes as a light brown carbonate associated with calcspar, which is invariably a constituent of these ores.

The chemical actions involved in pitting are of little practical importance, but the evidence points to the formation of a sulphide of manganese locally, by an adhering particle of manganese absorbing sulphur from the metal.

Metallic manganese will form pits as readily as will the manganese ore or pyrolusite, so that evidently it is not merely a case of corrosion due to a peroxide.

Weathering of Spent Ore Advantageous.

A precautionary measure against pitting, which is undoubtedly effective, is the weathering of the ore. For this purpose the ore as it comes from an oven is carried out and deposited in an open space, sprinkled with a small amount of salam-

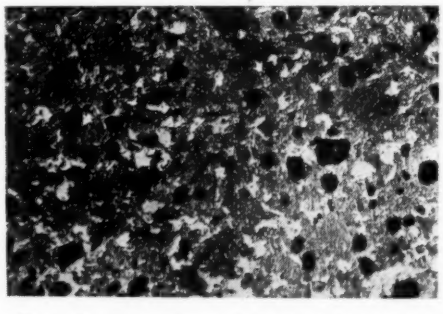


FIG. 12.—IS A CENTRE SECTION OF AN ANNEALED IRON, AND EXHIBITS VERY FINE AMORPHOUS CARBON AND PEARLITE. EXCELLENT PHYSICAL PROPERTIES ARE ASSOCIATED WITH THIS.

moniac, and left for a week or more, being turned over at intervals and after showers.

A fairly vigorous re-oxidation of the black ore takes place and considerable heat is evolved; it will be remembered that black ore as it comes from the oven is in a very reduced state and contains spongy metallic iron as well as the magnetic oxide (Fe_3O_4). Much of this is surface-oxidised in the weathering back again to hydrated Fe_2O_3, which gives it a greater potency in annealing and minimises the amount of red oré subsequently to be mixed with it for re-use.

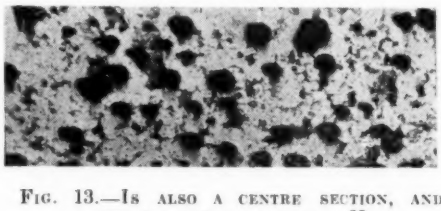


FIG. 13.—IS ALSO A CENTRE SECTION, AND SHOWS COARSER CARBON. NOTE THE FERRITE AND PEARLITE STRUCTURE.

Castings that have been in salammoniac weathered ore have a silvery or bronzed appearance, due probably to the deposition on their surface, during heating up, there being a thin film of ferric chloride which is subsequently reduced to the metallic state. This film probably acts catalytically as an accelerator of annealing, or at least of the decarbonisation part of the process.

Peeling.

This is a more serious defect than pitting, as the physical properties of a badly peeled casting render it quite unfit for use, and even machining stresses may disintegrate it (see Fig. 5).

There are three kinds of peeling, general, local, and skin peeling.

The first infers a general dislocation of the metal into laminæ as the result of a blow, the second is the local detachment of portions of the metal, the fracture being smooth and conchoidal. Both these defects are of common origin, but the latter is peculiar, mainly to the softer cupola metals. Although a pure pot-metal will withstand much more misuse than cupola metal, both kinds of peeling have been noted in the former, though naturally the same treatment would have resulted much more disastrously with cupola-cast metal.

If the annealing is to consist of an elimination of carbon, there must be two actions in progress, viz., a carbon removal and a carbon diffusion. Briefly, it would appear that if the diffusion is not sufficient to keep pace with the removal, a strained condition is produced which results in peeling.

Too prolonged an anneal at too high a temperature with unsuitable metal would give this fault and such work would be entirely useless. The fault of giving excess time to the anneal for this work causes all the carbon to be burnt from the metal. The carbon is extracted from the outside, and so long as there is a core of carbonaceous metal to feed this want then the metal will not peel. When the carbon has all been diffused through the metal, the final metal is very easily attacked by oxygen and oxidation takes place (Fig. 9). This gives practically a pure iron core with an oxidised skin.

In local peeling, sulphide films have been found in the metal between the dislocated surfaces (Fig. 8). In practice diffusion is assisted by one or more drops in the fire, occupying in each case 24 to 36 hours and reaching as a lower limit a temperature of 700 to 750 deg. C. Peeling is not simply over-annealing, as a casting may be over-annealed and not peeled, and *vice-versa* it may be peeled and yet insufficiently annealed in its thicker sections. For the complete prevention of peeling, either a regular metal or one of known variation is required, so that suitable ore strength and positions in the oven may be ensured. Skin-peeling is not a serious defect as it affects only the outer surface, the peel being hardly the thickness of paper. It has occurred in the anneal of soft cupola-metal which thus has been prolonged.

The analysis here appended shows that sulphur plays an important part here, forming a segregation towards the surface, and especially in the peeled portion: Sulphur in body of casting, 0.49; sulphur in peeled portion, 0.80; and silicon, 0.84; per cent.

Peeling and Burning of Castings.

In this case severe decarbonisation takes place and the crystals are considerably enlarged with the excessive heat. Oxygen penetrates then between these enlarged crystals and oxidation takes place. The bad effect of this oxygen can readily be seen when it is said that the cement between the crystal grains is much stronger than the crystals themselves (Figs. 11 and 12). The reason for a fine-grained metal having superior properties to a coarse-grained metal is because the latter has a larger ratio of area of cement to area of crystals.

With overheating, the grain size throughout the casting is made larger, but oxygen does not penetrate very far into the casting.

Another phenomenon takes place, namely, that the phosphorus, especially when in large proportions, segregates and flows into these enlarged grain boundaries, causing inter-crystalline weakness which ultimately produces the bright, coarse, crystalline fracture so well associated with burnt metal.

With regard to "peeling," this state of affairs cannot definitely be proved to be the outcome of burning. Although burnt specimens usually show signs of peeling, specimens showing peeling are not necessarily burnt.

Theory of Peeling and Co-efficient of Expansion.

The author submits the following theory as to the cause of peeling. As previously stated, the metal near the surface is greatly affected in carbon content through decarbonisation and then the re-carbonisation and penetration of oxygen. Excessive carbonisation of iron is known to produce an alloy which has a different co-efficient of expansion from the low carbon metal. (This point is illustrated in case-hardening steel producing an excessively deep case, high in carbon, which breaks away from the soft core). Will not this re-carbonised area behave in a similar way and break away from the decarbonised area, giving one likely reason for the phenomenon of peeling?

If oxygen is present also, it may oxidise the carbon out, tending to produce a low carbon area; but then the oxygen may oxidise the iron also and cause expansion of the outer layer of metal, producing peeling. Summing up, peeling most probably is due to (1) excessive carbonisation of the outer layer of the decarbonised area or rim, (2) oxidation of crystal boundaries, or (3) both above causes.

Primary Graphite Present before Annealing.

This very seldom takes place except in heavy section castings, and when this is the case the silicon and total carbon are high. This phenomenon was obtained in two cases of heavy sections, the carbon in the first case being considerably over 3.00 per cent. before annealing, and 2.78 per cent. after, whilst the silicon was 1.01 per cent. In the second case the carbon was over 2.80 per cent. before annealing and 2.50 per cent. after. The silicon in this case was 1.35 per cent. The original dendritic structure of the casting is persistent after annealing, near the place the primary graphite was situated.

The fracture of the specimen shows a dove-coloured rim, and in some cases a cloudy appearance, containing this and other colours. Especially with heavy sections, samples should be broken to ensure that there is no grey or mottled fracture showing this trouble.

Effects of the Annealing Heat on the Skin.

This skin-effect is almost invariably present after annealing, and it is caused in the first place by carbon being oxidised out, leaving a ferrite rim.

In some cases where the sulphur to manganese ratio is too great, the carbon is so firmly combined in the pearlite that it will resist being driven out and consequently a fairly hard skin is left, sometimes difficult to machine.

Altos Hornos de Vizcaya.—This Spanish concern reports for 1922 profits totalling 6,052,717 pes., which, added to the amount brought forward from the previous year, represents a sum of 7,441,335 pes. (say £248,000) available for distribution. The dividend is to be 30 pes. per 500-pes. share (6 per cent.), free of rates and taxes. The number of shares issued is 200,000.

AN ASSOCIATION OF LARGE USERS OF BRASS AND COPPER (sheet and strip) has been formed to secure mutual co-operation and to promote the welfare and interests of members in relation to supplies of sheet and strip brass and copper. Manufacturers using 140 tons per annum, or more, are invited to write to the Secretary, Mr. Percival P. Richards, F.C.A., Box 18, Chamber of Commerce Buildings, Birmingham.

THE WORTHING BOROUGH COUNCIL have made an application for a loan to cover the cost of extensions at the electricity generating station. A heavy oil engine and dynamo set, of a capacity of 750 kw., a 15-ton overhead travelling crane, centrifugal motor-driven circulating water pumps, with piping, tanks, etc., and switchgear and cables are to be installed, and the power station is to be enlarged. The loan applied for amounts to £18,000.

THE PROSPECTUS of the Mansfield Engineering Company (1923), Limited, will appear on Saturday. The business was founded 23 years ago, and the present company has been formed in order to equip further the New Hucknall works, provide a railway siding and additional working capital with a view to more economical production. The capital is £100,000 issued in £1 shares, and 62,500 will be offered to the public.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspond nts.]

Physics of Cast Iron.

To the Editor of The Foundry Trade Journal.

Sir,—Allow me to thank you for the report you have given my Paper on the above subject in your issue of March 29, and also for the criticism by Mr. J. E. Hurst.

The amplifications you asked for on page 259 are (1) In blowing air into a blast furnace, exidising agencies are introduced which can act on the graphite, whilst in the electric furnace there are no such oxidising agencies.

(2) In para. 7, page 257, in your interpretation of my term "primary temperature," you add "(to which the molten metal was raised.—Ed.)" My meaning of primary temperature, however, is that *inside of the blast furnace.*

(3) In the last paragraph of column 1, you refer to a "chronological error," which, however, is explainable by stating that Mr. Wood was in England in early 1911, and my discussion on carbon control was at the New York Congress of the I.T.A. in 1912.

On page 260 you have a little immaterial error, for in the last line your printer has transcribed the word "amply" to "simply," and this sentence snould finish "he is *amply* satisfied."

REPLY TO Mr. J. E. HURST.

With regard to Mr. Hurst's criticism, he states that I "studiously avoid" any direct reference to rates of cooling, which shows that we are looking at the subject from totally different angles. When I speak of *primary* temperature, it refers to that *inside* of the blast furnace, taking the temperature of casting into pig beds, and secondary temperatures, *i.e.*, rates of cooling, etc., as normal works conditions. For the best part of 20 years I have used the term "temperature and time" applied to the reduction of iron *inside* of the blast furnace, and it has been most amazing to me that, except for blast-furnacemen, my reference has always been translated into casting temperature and rate of cooling only. So long as he (Mr. Hurst) continues to look at my statements of the influence of "temperature and time" in the light of rates of cooling, we will never reach a common basis for discussion. It is quite apparent to me that Mr. Hurst has not fully grasped the principles dealt with in the Paper, *i.e.*, temperature and time *inside* of the blast furnace.

It is perhaps a coincidence that on March 9 last, in my lecture on "Carbon in Cast Iron," the following was the opening statement:—

"For nearly a quarter of a century the author has systematically studied this subject, and has long since come to the conclusion that there is less known respecting the true influence of carbon in pig-iron and cast-iron than any other impurity, owing to the common belief so long and tenaciously held that the impurities other than carbon chemically and physically control carbon, and therefore its general influence on the structure of cast iron, as also tests, etc."

It is quite true that Moissan was concerned in trying to make synthetic diamonds, but he fortunately put on record the details of his numerous experiments, and if he himself, not having the necessary knowledge, could not apply them to blast furnace practice, that is no sound reason why this should not be done by others with the necessary experience. Incidentally, Sir Roberts Austin confirmed Moissan's experiments, and produced synthetic diamonds *from pig-iron* (Royal Society's Journals).

As the best way of answering Mr. Hurst, may I be allowed to ask him certain questions? With all due deference to the classical Papers to which he (Mr. Hurst) refers the irons and alloys for which were all melted *in crucibles*, would it be reasonable to attempt to apply these results to the blast furnace and its products? That the addition to cast iron of silicon or manganese, etc., in the crucible gives one fracture whilst, when either of these is added in the blast furnace, each is capable of, and usually does, give another fracture, is simply a statement of "ascertained fact" and not of either theory or assumption.

It is very difficult to understand Mr. Hurst's criticism of the cooling curves, for, after going over all possible ways of showing how they *may* be wrong, he sums up as follows (page 262, para 4):—

"These proofs, as they stand, therefore afford us conclusive evidence* . . . that a percentage of the graphite is not absorbed on re-melting." Which is exactly what is stated in my Paper.

Mr. Hurst states that my conclusions with regard to absorbed graphite are *based* upon the two cooling curves. He is, however, making a statement which, whilst it may suit his own argument, is made without any knowledge of the facts, and it is not therefore surprising that he is entirely in error. First, the curves were given as one of *several* illustrations, and *he ignores the others.* Is this intentional, or has he just skimmed through the Paper and forgotten the other references?

Origin of Curves.

Now for facts. My opinion regarding high-temperature graphite in pig-iron not going into solution on re-melting was formed years before the curves were taken, and was the result of my own, and others, observations on the bad working of a Bessemer converter which, amongst other "observed facts," suggested to me the advisability of taking cooling curves from iron containing high-temperature graphite, and also from another iron containing low-temperature graphite. Having come to the foregoing decision of the cause of the bad blowing, and having selected a fracture of hematite containing low-temperature graphite, the trouble did not recur until iron containing high-temperature graphite was again used, when the other had unfortunately run out of stock.

This conclusion can therefore be said to be a statement of "observed and ascertained fact," but it would not be surprising for Mr. Hurst to deny this conclusion, because he has not been sufficiently fortunate to have the necessary practical experience to prove it to his own satisfaction. That, however, will not worry those practical-technical men and myself, who know and accept the fact.

Meantime, I quote the second paragraph of my Manchester Paper of March 9 last:—

"Some of the peculiarities in pig-iron, however, as disclosed by carbon (*i.e.*, fracture) can be simply illustrated. Those who are accustomed to the use of the acid Bessemer converter know that the following difficulties sometimes occur:—(1) The vessel is quickly scoured; (2) quickly 'gobbed up': (3) too much iron is oxidised; (4) the steel blows hot, but runs cold. It is not, however, generally known that these difficulties can to a large extent be foretold by the appearance of the fracture of the hematite, in other words, by the condition of the graphite, whilst, on the other hand, a smooth blow can be foretold in the same way."

Choice of Basic Curve Discussed.

Next let us consider Mr. Hurst's suggestion of the *possibility* of (1) oxidation of carbon on melting in the crucible, and (2) loss of carbon by gravity on cooling. With regard to (1), none of the learned investigators he quotes shows a greater loss than about 10 per cent., and I would remind Mr. Hurst that Andrew's grey irons I. and IV. and my "A" and "B" curves were taken at the same University, and presumably under practically similar conditions. With regard to (2), it is difficult to understand Mr. Hurst's suggestion that, at the temperature of 1,500 deg. C., carbon should be reduced by gravity on cooling, because, according to the equilibrium diagram, at 1,139 deg. C., iron should hold in solution 4.30 per cent. carbon, called the eutectic. This is taken from Carpenter and Keeling's diagram, which I prefer to Gontermann's which Mr. Hurst quotes, particularly as theirs also confirm Roozeboom. Above the temperature of 1,139 deg. C., the higher the percentage of carbon should iron absorb, for, of course, Mr. Hurst will have no doubt accepted the long-accepted theory that the higher the temperature, the more carbon will iron hold in solution. Further, whilst

* Mr. Hurst pointed out on page 319 of April 19 issue that this sentence should read "*no* conclusive evidence"; therefore the difficulty of understanding no longer exists.—Ed.

in Andrew's experiments the metal for No. IV. was quenched before use to give a white fracture, my alloy for curve "B" was not quenched, but cooled in air, whilst "A" was not previously treated in any way whatsoever.

Arithmetical Calculations.

Now, if I may be permitted to introduce a simple mathematical calculation, assuming in my curve "A" the T.C. was reduced by 10 per cent. to 3.80 per cent. on re-melting, according to Carpenter and Keeling's diagram, the first arrest should have taken place at 1,175 deg. C., at which temperature it should have been possible, with 1.00 per cent. silicon, for 4.00 per cent. carbon to be held in solution. Then let me continue the calculation further. In view of the fact that at 1,175 deg. C. iron, with 1.00 per cent. silicon, can hold in solution 4.00 per cent. carbon, does Mr. Hurst seriously suggest that in cooling down from 1,500 to 1,317 deg. C., the carbon was reduced from 4.20 per cent. (or 3.80 per cent.) to 2.1 per cent. *without any loss of silicon*, which is the most easily oxidisable constituent in cast iron, because, if so, it appears to me he is arguing against generally accepted pure science principles, which he seems so anxious to uphold.

Again, he says that one would *expect* (I hope he will exclude me as the exception to the rule) any undissolved graphite to rise as "kish" on cooling between the temperatures of 1,500 deg. and 1,317 deg. C.; does he realise that in saying this he admits my contention *in toto*, because he admits the total carbon at 1,500 deg. C. was 4.20 per cent. (or 3.80 per cent.), which is what I believe? To obtain *equilibrium* of carbon in solution, not only temperature, but *time is necessary*, the latter depending upon the original condition of the free carbon and providing the temperature is not too high so that high-temperature graphite in suspension could be formed.

Another curiosity in Mr. Hurst's criticism is that Gontermann's samples were also cooled down from 1,500 deg. C., and it took 15 minutes for the temperature to fall to 600 deg. C., so that the fall from 1,500 deg. C. to 1,317 deg. C. would occupy only about 4 min.; surely this is too short a time for graphite to rise when the percentage is much below the saturation or absorbing point at that temperature. Mr. Hurst accepts without question Gontermann's figures cooled from 1,500 deg. C.; why not mine from the same temperature-

Basis for Discussion Established.

In order properly to consider some of Mr. Hurst's other statements, it may be advisable to have the following table before us for easy reference, Part I. being taken from Carpenter and Keeling's equilibrium diagram and Part II. from the authors named. This will give us a base for discussion, as Mr. Hurst appears to accept all the results but mine:—

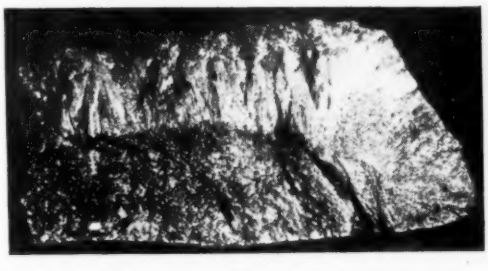
No.	Name.	C Per cent.	Si.	1st Ar.	2nd Ar.
Part I.—					
1	Carpenter & Keeling	4.30	—	1140	—
2	" "	4.00	—	1160	—
3	" "	3.50	—	1200	—
4	" "	3.00	—	1240	—
5	" "	2.75	—	1265	—
6	" "	2.50	—	1290	—
7	" "	2.00	—	1325	—
Part II.—					
8	Adamson "A"	4.20 (3.80)	1.02	1317	1090
9	" "B"	3.90 (3.65)	1.04	1216	1140
10	Andrews I.	3.92 (3.53)	2.52	1133	1133
11	" IV.	4.03 (3.63)	2.29	1156	1119
12	" V.	3.55 (3.20)	4.18	1140	1140
13	Gontermann	3.88	0.88	1147	—
14	"	2.75	0.90	1317	—
15	Turner & Hague	3.06 (2.76)	—	1245	1138
16	" "	2.56	0.97	1247	1136
17	" "	2.77	3.06	1202	1154
18	" " (Mn.50)	2.62	3.00	1210	1146

N.B.—Carbon per cent in brackets gives the T.C. less 10 per cent. loss on remelting.

Gontermann's 13 appears to be all pig, whilst 15 is an alloy.

It is unnecessary to discuss the above tables in every detail, for those who are able to follow the discussion can make their own comparisons, but why Mr. Hurst should select Gontermann's diagram it is difficult to decide, unless it be to show that pure science investigators also do not agree even in laboratory experiments. For instance, compare Gontermann's result 13 with my 9, as also No. 4, with Turner and Hague's 16, or Gontermann's 13 with Carpenter and Keeling's 5. In none of these do the first arrests agree, and very few agree with the equilibrium diagram.

It may be inferred from Mr. Hurst's reference to Gontermann that the first arrest (14) at 1,317 deg. C. instead of 1,265 deg. C. (5) was due to the higher silicon, but this is not confirmed by Turner & Hague's arrest (16), which suggests that silicon substantially *lowers* rather than increases the first arrest, which is also confirmed by their (17) experiment. Again, compare 17 and 18, where 0.50 per cent. Mn. does not appear to make any material difference in the first arrest. On the same T.C. and Si. Gontermann obtained 1,317 deg. C., Hague & Turner 1,247 deg. C., the former being 70 deg. higher than the latter. May I now be permitted to offer Mr. Hurst my explanation of the difference in the first arrest of these investigators, for it would appear to be impossible to deny that Turner & Hague's experiments show that silicon, *per se*, lowers the first arrest in cast iron. Mr. Hurst will probably have missed the meaning of one of Gontermann's most important preliminary statements, that Mons. Girod sent him a carburising medium, *i.e.*, cast iron containing 7.90 per cent. carbon, which abnormal percentage



The Fractured Sample from which Micro No. 4 was taken. It is Chill Cast.

Mr. Hurst will recall was mentioned by me in my 1911 Paper on "Carbon in Pig-Iron" (Iron and Steel Institute), when I first published the cooling curves, and gave Mons. Girod's results, which he had sent me privately. With this percentage of carbon the iron would undoubtedly be a grey fracture, *and the free carbon high-temperature graphite*. Now if my assumption, based upon "observed fact," is correct, that high-temperature graphite does not all go into solution, and also bearing in mind that, as shown above, reduces the first arrest, then, as Gontermann obtained 1,317 deg. C. with 100 per cent. silicon, assuming we add the difference of 70 deg. to this, we obtain 1,387 deg. C. for the first arrest with a pure iron-carbon alloy, which in Carpenter and Keeling's diagram represents 1.45 per cent. T.C. in solution, the remaining 1.30 per cent. being undissolved. This therefore would be quite in keeping with my results of curve "A."

Let me assure Mr. Hurst that I am not dogmatic on this assumption based upon Gontermann's work, as it is not my own, but taking Gontermann's and Turner and Hague's as they stand, I am only endeavouring to draw a logical conclusion with the assistance of elementary mathematics.

All Mr. Hurst's criticisms of my curves are based on *assumptions* on his part, but, unfortunately, he does not carry his arguments to a logical conclusion, and it would appear that Gontermann's curves, instead of disagreeing with mine actually confirm them.

As stated in the Paper, Dr. Carpenter agreed with me that the phase rule could not always be applied to works practice, and the above table would appear to prove that it cannot be strictly applied in comparing even laboratory experiments, yet Mr. Hurst wishes to insist upon its application to my samples, one of which was a virgin blast-furnace product and the other a laboratory alloy of white iron and silicon, the latter cooled in air.

A Question of Inclusions.

Mr. Hurst's criticism of Micrograph No. 4 is that as the micrograph was taken at the edge of the sample, what is called graphite may be other inclusions. He thereby totally ignores the statement in the Paper that this surface was cast on to an *iron chill*, and if he will kindly look a little higher in the micrograph he will see there is a similar crystallisation farther into the specimen, but in the hope of satisfying Mr. Hurst that there are no such inclusions a photograph of the particular fracture, about one-half the actual size, is given above. Perhaps Mr. Hurst will permit me to make a statement of "ascertained fact" from the fracture of the actual sample in my possession—*there are no inclusions except graphite throughout the chill.*

Mr. Hurst then states that none of my evidence is conclusive proof that the "molecular character of the graphite" is modified as a result of high temperature conditions, etc., etc. May I ask Mr. Hurst not to introduce his own phrases into the discussion, but to be good enough to keep strictly to mine, *i.e.*, "the crystallisation of graphite is the greatest factor in the *molecular physics* of cast iron."

In concluding, Mr. Hurst admits the "observed fact" that the temperature of production has a marked effect upon the characteristics of the final pig-iron, and he will no doubt recall that it was a long time before he agreed with me thereon. The following quotation from his article in "Engineering" of August 30, 1918, will be interesting:—

> Provisionally, with the facts at present at our disposal, it would appear that the influence of the temperature of production of pig-iron on the formation of free carbon is more easily explained on these grounds. In any case, it is of considerable importance to note that of the two *graphite is the primary constituent* to form in commercial grey cast iron.

I feel sure that Mr. Hurst is well on the way to accept other "observed facts," although they may not be his own and do not always conform to theory, also I hope that with the aid of my further explanations—drawn by Mr. Hurst's clever criticism—he will now be better informed with regard to the behaviour of free carbon or graphite in cast iron.

REPLY TO Mr. H. J. YOUNG.

It is a pleasure to cross swords with Mr. H. J. Young, because I know him to be a past-master in the science of chemistry, and it also gives me an excellent opportunity of discussing the pure chemical position in regard to the metallurgy of cast iron.

First of all, let me remind Mr. Young that cheap ridicule or bluntly denying a statement of ascertained fact does not disprove that fact, and I think Mr. Young has heard of a little incident in which a chemist refused to accept my data, although complete details were given, such as were repeated in my Manchester Paper. In reply to the chemist I suggested he should duplicate my tests and publish his own results, and he appeared to be afraid of doing this because of my possible criticism, which, of course, would be natural *if* the duplicate results did not agree with my own.

The whole of Mr. Young's criticism is destructive, and, unlike Mr. Hurst, he offers no constructive data to contradict me. Is this because he is afraid of criticism? Judging from his published work, he has a strong aversion to anything which is not "chemically controlled," and it may first of all perhaps be well to take him to task for his statement, "I no longer wonder why he (Mr. Adamson) sees so little in the control of cast iron by chemical composition." Were I discussing this with Mr. Young only, the matter could be closed by the following quotation from a recent private letter from a well-known chemist and metallurgist with practical experience in the iron foundry:—"The average analytical control is 90 per cent. nonsense." As my reply is also intended for the benefit of your readers, let me endeavour to storm what Mr. Young apparently believes to be his impregnable position of chemical control.

From his public utterances he claims that the present methods of analyses are only partial, that we should really have a *complete analysis;* and it would be well to state what this means. At present we are only concerned with Gr.C., C.C., Si., S., P., and Mn., but according to Mr. Young a *complete analysis* would probably include amorphous C. and Gr., Gr. C., C.C. (perhaps also the missing carbon), several silicides of iron, several phosphides, several sulphides, several combinations of Mn., Ni., Cr., Ti., Cu., As., also O. and N., in their various possible forms, and any other gases. Also various carbides of Mn. Cr., etc., as well as several other chemical compounds, of none of which there is absolute proof, etc., etc., together with the irregular "distribution" of C., owing to the presence of various compounds which hold little, if any, carbon. Will Mr. Young say how long it would take to do such an analysis, and if the various compounds possible and impossible can be accurately estimated; also what such a complete analysis would cost, and how many chemists it would take to run even a small foundry on these lines? Finally, what is their *intrinsic* scientific and practical value when completed?

Until such an analysis is customary in scientific papers it is always open to the pure chemist who can see nothing else but chemistry to say he does not accept *any* conclusions based upon ordinary chemical analyses such as we now understand.

Influence of Elements other than Carbon.

Now let us take the view of the metallurgist who happens to be a chemist and also a physicist, and who also possesses a fair amount of common sense, which, after all, is the greatest asset in the metallurgical world. The metallurgist possessing these attributes tries to apply physical as well as chemical laws to cast iron, and particularly if he has any knowledge of the analyses, etc., of the ores used in manufacturing pig-irons both for steel and for the iron foundry, he recognises that outside of C, Si, S, P, and Mn, any other impurities which may possibly be present are very low in percentages, and in iron-foundry work are negligible. One illustration will perhaps be sufficient to show the weakness of Mr. Young's attitude. The manganese content of my two cooling curves were "A," 0.53 per cent., and "B," 0.22 per cent., and it is perfectly true for Mr. Young to say that one Mn was more than double the percentage of the other, which misleading statement is surely comouflage, and I repeat that for all practical purposes these two percentages of Mn are practically the same. It is true there is 0.31 per cent. difference, which Mr. Young suggests is the cause of the difference in the cooling curves, but Turner and Hague, as previously quoted in my reply to Mr. Hurst, show that Mn 0.50 per cent. makes very little difference in the first arrest, which thus anticipates my statement. As Mr. Young accepts no work but his own, I do not ask him to accept Turner and Hague's statement and mine, and merely give it for the benefit of your readers.

On only one other occasion have I had such extreme statement of chemical influence in the criticism of my Papers, and it may be useful to quote it for the benefit of your readers as showing at what straws the pure chemist will clutch to support his own attitude. This was in 1909, when a chemist stated that the cause of one of two fractures of practically the same T.C. and chemical composition, being the one grey and the other white, was the percentage of S, *i.e.*, the grey fracture contained 0.026 per cent. S and the white fracture 0.049 per cent. S. Let me assure you that this is not a fairy tale, for this criticism is on record in the journals of one of our leading technical associations, but it is so utterly absurd as to need no comment.

It is unfortunate that Mr. Young introduces the word "camouflage," because it is quite evident that this suggests just what he is doing against his arch enemy "physics."

What Fracture Shows.

Mr. Young is quite right in stating that fracture discloses to me, and many others, much which he cannot see and neither chemistry nor the microscope can disclose, as, for instance, the appearance to the naked eye of a "dry" fracture; but there are many moulders probably working on the

floor of Mr. Young's foundry who could *show* him such a fracture. It has been my privilege to pick up many excellent points from practical men, upon which I have formed my own conclusions, and if Mr. Young will follow my example he will soon discover how to see a great deal more in fractures than he is able to do now. Possibly Mr. Young would be surprised if he had the opportunity of studying the structure of pearlite, etc., under different conditions up to 5,500 diameters, which it is my good fortune to be doing at the present time.

If any illustration were necessary to prove Mr. Young's *prejudice* against carbon control, it is that he denies that the condition of carbon governs the appearance of the fracture of cast iron, but in so doing he disputes a statement of what Mr. Hurst terms "observed fact," and whatever the difference in opinion with regard to the cooling curves between that gentleman and myself, he (Mr. Hurst) does agree with me in regard to the difference of graphite in controlling fracture. What *is* open to discussion is whether chemistry or physics have the greatest influence in controlling the condition of the carbon.

Now, if Mr. Young knows of other elements which have an effect on molecular physics of cast iron as well as carbon, why does he not give them? Is he afraid of my criticism?

Mr. Young states "it is not true that the grain cannot be closed except by low-temperature pig-iron." Surely he has overlooked page 259, para. 2, where it is explained in detail how high-temperature large-flake graphite can be *materially* modified in iron-foundry practice.

It is admitted also that it is quite possible to obtain high-silicon close-grained pig-iron with low T.C., but this is begging the question, as it has not been mentioned in my two Papers.

In his description of closeness of iron and strength, Mr. Young puts the cart before the horse, for it is again an "observed fact" that closeness of grain and strength of cast iron go together *because* of the smallness of the graphite. Had Mr. Young followed the whole of my published work since 1906 he would find tables and other data in support of every statement made in these two and other Papers. He will also find that it has been my custom to ignore all theory which cannot be proved in works practice. This includes chemical *control* of the molecular physics of cast iron, but as soon as Mr. Young can publish data satisfactorily to prove his attitude without any reference to physics or equilibrium, he will no doubt receive a large following. At the moment, however, the drift is all in the other direction.

One more reference. Mr. Young states that had his assistants presented him with the cooling curves he would have demanded further work thereon, including quenching or chilling experiments, and in regard to the latter method of preparing the metal from which to take the cooling curves, Mr. Young shows that he does not understand the elementary principles of the influence of pressure on rapid cooling, as chilling would have the effect of splitting up the brittle graphite into small particles, thus producing the equivalent of carbon in solid solution, and hence producing different results from the *natural* one, obtained by using "kishy" grey iron in such a way as it is necessary in ordering foundry operations. Further, Mr. Young's suggestion of preparing his samples for cooling curves by chilling would be of no practical value to the iron foundry, and on these grounds they would be only of academic interest.—Yours, etc.,

E. Adamson.

19, York Street, Sheffield.
April 19.

[For the benefit of our student readers, it is necessary to state that definite compounds such as Fe_3C, MnS, etc., do exist in cast iron, and that once the percentage of elements are established the use of chemical arithmetic and a knowledge of the constitution of the constituents is all that is necessary to convert an ordinary analysis to a constitutional one. Metallurgical students would be well-advised to disregard the whole of this controversy, if they are preparing themselves for examination, and keep to the views as set out in the standard text books.—Ed.]

Value and Relation of Test-Bars to Castings.

To the Editor of The Foundry Trade Journal.

Sir,—With reference to my article bearing the above title which appeared in The Foundry Trade Journal of March 29, Mr. J. Shaw, in his letter of April 12, remarks there are several points raised which are open to criticism. This is admitted, but I wish to ask that, unless a very good purpose can be served, is it desirable to pursue this aspect if the Test-bar Committee have finally reached their decisions?

The closing paragraph of Mr. Shaw's remarks referring to old types of testing machines, bears no reference to any statement of mine.

Referring to pressure tests being of more importance than test-bars, Mr. Shaw states that "he (myself) forgets that bedplates and frames, fly-wheels, etc., require to be equally strong, and some test is needed."

I do not forget such important items. If my statements are read carefully, it will be clear I was referring to some castings where the supply of test-bars should not necessarily be enforced followed by examples of pressure-tested castings, etc.

Also I intended to make it quite plain that test-bars for castings, such as have been referred to, can be obtained in one size standard test-piece respectively for tensile, transverse, compression and hardness.

I am not concerned with the anomalies of the American specification. My concern is for a simple test-bar that will satisfy the engineer as to the strength of the material

Mr. Shaw refers to white, mottled and grey bars. Such is foundry procedure for our own information. Those of us who have been responsible for the production of various castings have our own way of obtaining certain desired results. If these were enumerated it would be a long story.

I still adhere to the opinion, that for commercial grey iron castings, all that the engineer requires can be embodied in one size standard bar, or piece, for the various tests already named.—Yours, etc.

S. G. Smith.

April 16, 1923.

Drying Sea Sand for Oil Cores.

It is debateable whether it is advantageous to dry sea sand, but we are of opinion that time will be saved in mixing with the oil if the sand is dried. On a recent test, the time for mixing 1½ cwt. of sand was reduced from 4½ to 3½ minutes. It can be imagined that by drying the sand is more fluid, and is thus in a better condition for mixing. On the occasion of a recent visit to the Midland Motor Cylinder Company, Limited, of Smethwick, we noticed a very simple yet efficient apparatus specially designed for drying sea sand. It utilised the principle that sea sand flows when dry. The apparatus consists of a sheet-iron tank the cross-section of which roughly resembles the letter W. At the base of the two Vs which go to make up the letter W a ¼-in. slot is left open, and between the two Vs is a perforated gas pipe, which serves as a burner. The two Vs are filled with damp sand and the burner is lit. Obviously, as the sand is dried and the surface tension due to the presence of water is destroyed, the sand slowly, yet constantly, leaves the machine through the slots at the base of the two V sections. The machine is manufactured by the Pneulec Engineering Company, Limited, of Smethwick, near Birmingham. This machine could be advantageously used by the acid open-hearth steel manufacturers who require a constant supply of dry silver sand for fettling purposes.

Catalogues Received.

Moulding Sand. Messrs. Geo. H. Proctor and Son, of Flass House, Durham, have sent us a descriptive booklet illustrating the Flass Quarry and its three products—moulding sand, building sand, and a refractory sturry. The descriptive portion of the pamphlet is taken from Prof. Boswell's well-known book on British Resources of Refractory Sands, whilst the analyses have been supplied by Messrs. H. F. Harwood and A. A. Eldridge.

XUM

Institution of British Foundrymen.

NEWCASTLE BRANCH.

Discussion on Mon. E. V. Ronceray's Paper on "Facts about Sound Castings, Feeding Heads, Runners and Venting."

The Branch-President (Mr. H. J. Young) called upon Mr. Smalley to open the discussion.

Mr. O. Smalley said he was afraid that Mon. Ronceray had misquoted his Paper in one or two instances. At the outset the lecturer had referred to the disc experiments, and said that he had eliminated the defects due to porosity by correctly venting the mould. His (Mr. Smalley's) experiments were not to show porosity. M. Ronceray had apparently confused the terms, porosity, blow hole and shrink hole. It is important to differentiate between the terms porosity, shrinkage and shrink holes, liquation and gas cavities. If the lecturer would kindly refer to the speaker's Paper, he will observe that his experiments were to demonstrate the constitutional changes of cast iron with a falling temperature, and the defects referred to are blow holes and shrink holes due to pouring with cold iron, and have nothing to do with porosity.

The second instance was the stuffing box. M. Ronceray stated that, by correctly venting the speaker had eliminated porosity. That is not so. No mention was made of venting. The example was chosen to illustrate how, with a change of section such as that particular casting presented, trouble due to porosity could be eliminated either by pouring slowly with very hot metal or, preferably, by chilling. Venting did not play any special part in this instance.

In making reference to the special K test bar, designed to investigate selective freezing or crystallisation of various cast irons, he again regretted some little misunderstanding on the part of M. Ronceray, who, in *his* experiments, had used a green-sand mould at about 60 deg. Fah., whereas Mr. Smalley used a dry-sand mould at 100 deg. Fah. In making such comparisons, it is essential to have a clear conception of the object of the test; in this instance it is selected freezing and volume change; therefore, the mould must be run as stated in the Paper, and filled completely with liquid metal, so that solidification sets in at the same time throughout. The casting must then be sectioned carefully, polished and etched through line A.B. obtained from the isothermal lines. The defect might easily be missed in cutting, so machining must be done with care. It is not sufficient to saw through the casting. M. Ronceray showed an illustration how he had obtained the casting sound with a 3½ per cent. silicon iron, observing that this was in direct contradiction to Mr. Smalley's results. This is not so. Photographs A-B, Fig. 61,* show how the draw can be reduced with an iron of long-freezing freeze, such as that used by M. Ronceray, by simply running slowly with very hot metal. Other experiments given in this Paper* show how solidity is increased by cooling more rapidly. Therefore, M. Ronceray, by using a green-sand mould and running slowly, exactly reproduced the result anticipated. Unfortunately, he (M. Ronceray) went on to say how the defect could be reproduced at will by altering the venting of the core. If M. Ronceray's illustrations are referred to, it will be observed that the defects shown are blow holes, and have nothing to do with the shrinkage defects referred to in the Paper. Incidentally, he was investigating something entirely opposite to the object of the original experiments. His (M. Ronceray's) illustrations clearly show that the metal has washed away a part of the core, and the defects shown are always obtained when this happens; they are a result of carelessness or negligence on the part of the moulder. It should be emphasised that in his (Mr. Smalley's) research it was essential to adopt standard conditions throughout, and he endeavoured to investigate one variable at a time. In the casting under discussion the core was made of specially-prepared loam of low gas-content and high permeability. It was made by the same moulder throughout the whole of the experiments. In considering the problem from M. Ronceray's point of view, it is important not to confuse the gas in the metal with that in the mould.

* See Foundry Trade Journal, issue Feb. 1, page 93 "Volume Changes of Cast Iron on Solidification," by Mr. Smalley.

Jet Running.

In his Paper, M. Ronceray made mention of jet running. One could not undervalue this as a factor in producing sound castings. The principle of jet running was to secure a gentle flow of metal and obtain simultaneous solidification conditions throughout the casting as far as possible. He (M. Ronceray) had demonstrated very forcibly that, by making use of this factor, improvements could be effected. There is some explanation, however, for every phenomenon, and the failure of other experimenters must not be discounted. It is from failure that we learn, and the explanation of their results can only come from establishment of fundamental principles. M. Ronceray has not mentioned these. To fix correctly the rate of running of a casting, for example, one must know the available heat in the metal, *i.e.*, the temperature of the metal and the latent heat of solidification, and also the range of temperatures through which the metal solidifies. Without this information the foundryman must either depend upon past experience or chance. It is, of course, very interesting to hear that all porosity and draw holes, defects so common to iron castings of varying section, are due to incorrect venting, but unfortunately this cannot be substantiated in practice. One must at least credit the moulder and core-maker with an understanding of the principles of venting and with being able to differentiate between a defect such as a draw, due to metal or design, and a blow hole from the core or mould. Mr. Smalley did not think M. Ronceray had produced any evidence to convince that porosity and spongy places were due to incorrect venting of either the mould or core. In the case of the motor-car cylinders and pistons referred to, the porosity at the change of section is a question of volume changes on solidification and of selective freezing. It is closely associated with pouring temperature, composition of metal, method of casting, rate of cooling and often with design; special venting of the cores, which, although commendable, will not eliminate the defect.

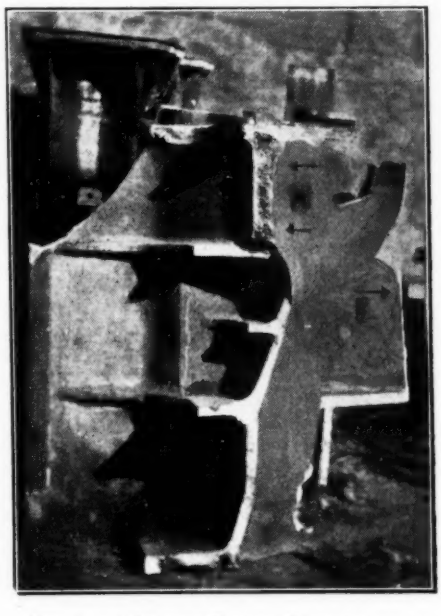


Fig. 1.—A Marine Engine Cylinder showing Defect at A. The Barrel is at B.

Contributed Discussion.

It might not be out of place, whilst considering this defect, also to exemplify a marine engine and a locomotive cylinder. Fig. 1 illustrates a marine cylinder, weighing 10 tons, after sectioning through its length at the position where defective. This cylinder was rejected owing to open grain in the barrel and leaking under water test. The nature of the defect is shown by the photograph, and is internal. It was local to two positions of the cylinder, where three sections merged. It was cast vertically in the position shown by the photograph. The composition of the metal was as follows:—T.C., 3.43; Si., 1.97; P., 0.92; Mn., 0.76; and S., 0.084 per cent.

Without modification of the method of construction of either cores or mould in any way, or in the method of running, the defect was eliminated by speeding up solidification at this change of section and using a metal which, according to the volume change experiments and reasoning in the speaker's Paper, suggested itself as more suitable, viz., T.C., 3.12; Si., 1.40; Mn., 0.85; P., 0.35; and S., 0.080 per cent.

The loco. cylinder example is shown by Fig. 2, exhibiting the crystalline nature of the draw at the junction of five sections. This cylinder was rejected for exactly the same reason as that cited above, and the small pine tree dendrites clearly shown were similarly exhibited by the draw in the M.E. cylinder. The following metal was used:—T.C., 3.41; Si., 1.83; Mn., 0.79; P., 0.82; and S., 0.056 per cent.

Cylinders of this type were cast both vertically and horizontally, run from both top and bottom, fast and slowly. Cores were tried in loam, rammed sand, and also in oil sand. Venting received special attention. The defect always appeared at this place, and had the form shown.

On completion of the volume change experiments, it was decided to cast vertically, because this lent to slightly better feeding of this particular section of the cylinder, and use the following metal:—T.C., 3.0-3.2; Si., 1.25-1.35; Mn., 0.7-1.0; P., 0.2-0.35; and S., under 0.10. This completely eliminated the trouble.

Chills were also used, however, but rather as an extra safeguard, for the section was a little more complicated than that used for the K bar tests.

Figures A, B, C and D (Fig. 3) show how the pine-tree form of crystal develops in the defects which are encountered at the change of section in a casting, A depicting incipient solidification, B, C and D progressive solidification, if a supply of the lower melting point material is forthcoming. Thus, cast iron solidifies by this skeletal growth. If this takes place slowly so that full development of the crystallites is possible and the iron used has a wide range of freezing temperature, then at a change of section, if supplies of the lower melting point material are shut off, the skeleton structure of B, and maybe a cavity as well, are left.

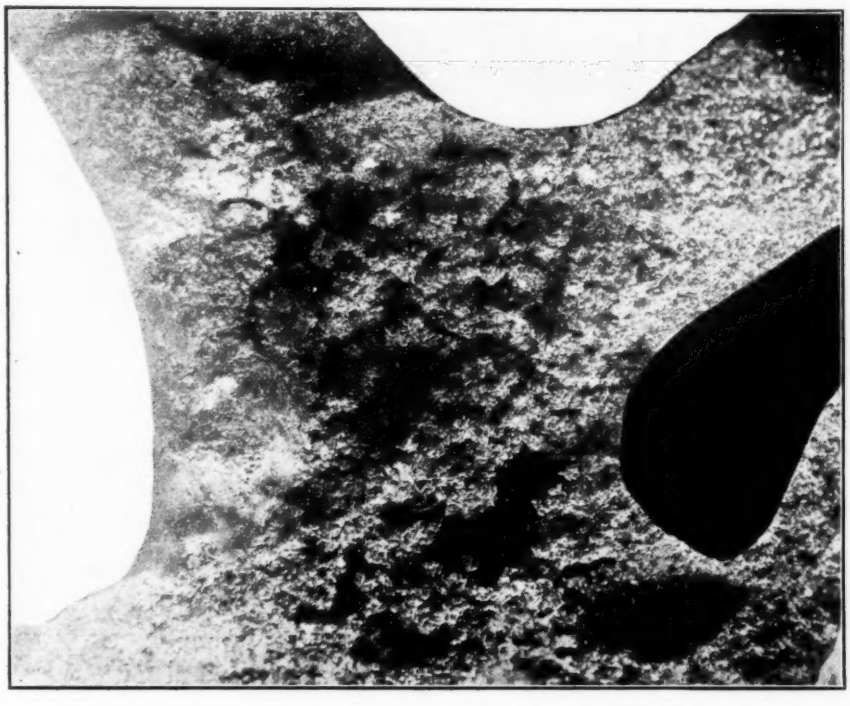


FIG. 2.—A REJECTED LOCOMOTIVE CYLINDER THROUGH LEAKAGE UNDER TEST.

Feeding of Castings.

It is carrying it rather far to say that the feeding of castings is not necessary, as, apart from selective crystallisation, normal cast irons do shrink under certain conditions. One may instance, for example, a large cylinder run from the bottom. The greatest draw is invariably at the upper portion of the casting farthest away from the ingates, *i.e.*, it is due to the temperature fall of the metal as it rises in the mould.

To obviate this defect one must either introduce top pouring or run off some of the metal from the top of the casting.

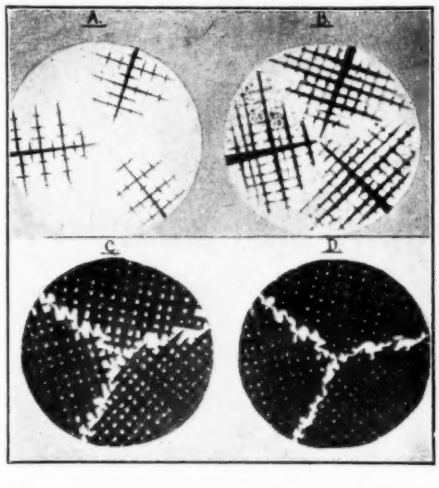


FIG. 3.—SHOWING THE GROWTH OF CRYSTALLITES IN METALS.

Ingot Mould Making.

MR. WILSON said that he had always been interested in M. Ronceray's careful experiments and observations. They had made a great number of castings, similar to that shown by M. Ronceray, of a marine valve weighing 6, 7 or 8 pounds, and used to get about 75 per cent. failures, but now that they used M. Ronceray's practice, they had no trouble with them whatsoever. They had also made experiments with larger castings, and got equally successful results. They were running 5-ton ingot moulds with runners on very much the same lines. Instead of having one large runner and pouring the metal in quickly, and feeding for about half an hour, they used three or four small runners. It took from 1 to 1½ min. to fill the mould, which hardly had to be fed at all. He had seen 50-ton moulds which only had to be fed with 60 or 80 pounds of metal. Heavier castings were obtained by this method, which meant that they were getting more metal into the moulds.

Steel Manufacture.

MR. STOBIE said a reference to the casting of steel might help the members to gauge better the cause of the blow holes which they found in iron castings. He mentioned the case of up-run ingots which had been quickly solidified at the top by means of chills or by water, and said that, if blow holes originated from the metal *per se*, they would be fairly evenly distributed. If the metal were poured very hot and the ingot moulds were cold, the result would be a subcutaneous arrangement of blow holes. Practically the same happened if clay wash was used for preparing an ingot mould. Blow holes arising from the condition of the metal had a greater tendency to rise upwards through the metal than had those which originated from the condition of the mould itself. The shape of the holes, in the former case, would be after the style of an inverted pear.

It had been suggested that, by jet running, the whole of the metal solidified at one and the same time, but he did not agree with that. Taking the case of the casting of a solid cube, if the metal solidified all at once, there would be a greater amount than usual of concave sinkage at the top of the cube, which is contrary to what is found as the result of jet running. Another difficulty in accepting the theory of all the metal solidifying together was that it was scarcely conceivable that the whole of the metal was at precisely the same degree of temperature, no matter how the mould and runners were made.

M. Ronceray's point about the effect of slag upon metal was well realised in steel casting. The slag reacted on the molten metal, and, if the slag were at the surface of the metal, the resulting mechanical stirring of the metal would cause it to take up oxygen. This oxidation would act adversely on the nature of the metal.

Slag inclusions were the cause of certain unsoundness in steel castings, and Mr. Stobie did not think that he had ever heard of iron founders paying the slightest attention to the probability of slag also being the cause of considerably reduced strength in iron castings. With hot metal, there was more chance of the slag getting away, and consequently this trouble would be greatly eliminated thereby.

Casting Trouble.

MR. J. W. FRIER asked M. Ronceray's advice about some small castings with which he had had trouble. The castings were about 8 in. dia. and 2½ in. thick, and the trouble was due to porosity and large gas holes.

They had tried putting a head on the casting about 9 in. high and 2½ in. dia., but that did not have any effect. They also put chills in, but the castings were as bad as ever. Then they made them in three-part boxes, and were fairly successful with the ordinary jobbing iron, but when made with special iron, the castings were faulty. Then someone suggested casting when in open sand, which they did, and obtained reasonably good castings. For the mould they mixed ordinary facing sand with about half as much sea sand to make it porous, and were fairly successful on the whole. He would like to know how it was that they could get the castings solid in open sand, but could not get them solid within a mould.

Porosity in Cylinders.

MR. S. W. WISE said that he agreed with M. Ronceray with regard to the filter runner, and also that slow pouring was in many cases more successful than quick pouring. He had understood M. Ronceray to say that porosity was due to the non-escaping of the gases, but he did not entirely agree with that. With regard to the motor cylinder which M. Ronceray had spoken about, did he mean that the porosity existed at the top of the cylinder?

Receiving a reply that the porosity was found between the two bores, and that in about 99 cases out of 100 it was due to non-escape of gases, Mr. Wise asserted that his experience was entirely opposite, and he always found the porosity where two or three sections joined together, and the same applied to the case of the motor piston. He cast pistons day by day, and his practice was absolutely standardised. The sand was always the same, rammed the same and dried the same, and he did not see that the porosity, sometimes arising in gudgeon-pin bosses, arose from non-escape of gases, considering that his moulds were always alike, and, in his opinion, it was a metallurgical question. Gas would always be more likely to strike through the soft core than through the metal.

He would like to know how M. Ronceray thought the ribs could affect the gudgeon-pin bosses, and whether he thought they made the sand more porous.

Receiving a reply that there was greater heat when ribs were used, and when the gases escaped through the sand the castings were good, but when they escaped through the metal the castings were wasters, Mr. Wise continued by referring to a motor piston, and saying that his daily practice did not alter and that the permeability of his moulds was always the same, and the gases would not have to escape through the metal. He thought that in nine cases out of ten porosity was caused by drawing, due to the mixture of the metal.

The lecturer interposed that he thought that porosity might be due to improperly dried cores, and that the idea of drawing in sections 1 in. thick at the most was absurd.

MR. WISE said that he was referring to cores which were dried at a known temperature and left in the stove for a certain period, and which had a known mixture of sand and which was always treated the same.

M. RONCERAY asserted that the average man was not absolutely regular in his work, and that it was almost impossible to do exactly the same thing day in and day out, and it was very difficult to get the cores dried exactly the same every day. For instance, the atmosphere varied so that it was impossible always to get the same temperature.

MR. WISE said they used a recording thermometer, and were able to tell the exact behaviour of the stove. He thought that porosity was largely due to malformation of crystals.

Simple Castings Difficult to Make Sound.

MR. R. O. PATTERSON said that most people used a breaking ball for smashing up castings, and sometimes, instead of breaking the castings, they smashed the ball. When that happened, a large shrinkage place could generally be seen in the centre of the ball, and he would like to know how that hole could have been affected by the sand or gases, the ball having been fed properly for about one hour until it was solid.

Lately they had had a little trouble with axle boxes, which were drawn round about the oil-sand core at the bottom of the casting, and the remedy was to cast them very hot. He had always found that small simple castings gave the most trouble and were the most difficult to get sound, and he thought that M. Ronceray had given a very valuable solution of the problem.

Large Graphite and Unsoundness.

MR. BINNS referred to motor pistons, and said they were turning out hundreds of those castings, when suddenly the piston bosses began to be porous. The matter was taken up by their laboratory, and the chemist saw that the analyses were identical, and he himself saw that all conditions were the same in the foundry, and yet, when they

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compared two bosses, one was sound while the other was porous. They found the solution of the problem in the use of photomicrographs. When photographed, they found that the graphite plates were much larger in the porous boss than in the sound boss, and, by refining the graphite in the metal, they were able to surmount the difficulty.

Written Contribution.

Mr. H. J. Young wrote that it seemed to him that the main purpose and objective of M. Ronceray's teachings was being obscured and, having earnestly read everything that M. Ronceray had written during the last year or so, he (Mr. Young) held the opinion that M. Ronceray was nowadays giving too much attention to the proving or disproving of other people's ideas, and that what they wanted was M. Ronceray's ideas. M. Ronceray was turning out very large quantities of good castings by his methods, which was sufficient proof, and needed no argument whatsoever. That many troubles cannot be solved by M. Ronceray's methods has got nothing to do with the case. He claims no profound knowledge of theoretical metallurgy and, therefore, it is obviously impossible for him to define the true *cause* of many difficulties in castings, even if some of the difficulties are successfully eliminated by his methods.

Mr. Smalley's work is extremely interesting and valuable, but it cannot disprove M. Ronceray's work no more than M. Ronceray can disprove Mr. Smalley's work. They have little in common, are upon different lines, and devoted to different objectives.

Difficulties of Scientific Control.

It amazed him (Mr. Young) to hear foundrymen claiming that they conducted their foundrywork as an exact science, that their sand, their metal, their core-making, their mould-ramming, their drying operations, their cupola practice—indeed, everything possible is, in their own words, "day in and day out under control and always the same." They might be surprised to learn that a trained observer can, by the application of one test, and one test only, on any of these things, prove that they are never twice alike save by mere chance. It had always appeared to him to be a pity that our technical schools do not devote a little time to teaching and demonstrating the extraordinary difficulty of producing two things alike or of doing a thing twice in the same manner. Almost everything in the world is an example of the truth of this, and most of those things which appear to be alike prove very different when a simple test is applied.

In foundrywork, we have hardly started to control the various operations. Cast two test-bars in the same mould from the same ladle and the same runner—will they weigh and measure the same? Will each have the same flaws and defects, or lack of them? Will they give the same results in tensile, transverse, brinell, impact and crushing tests?—if not, why not, considering that *apparently* everything has been controlled?

M. Ronceray's methods are, to an unskilled man, little else than sheer common sense. Turn a water-tap full on and it will give a good idea as to how the molten metal enters into many castings. In common language it is "asking for it." If M. Ronceray can only slow us down a little, he will have rendered a great service to general iron-foundry practice in this country. Very many faulty castings are caused by dirt, slag and air, one or all, being poured in along with the metal: others by the great speed, force and volume of the in-rushing fluid; others by lack of porosity in the sand, or by the method of pouring being such that the sand, however porous, cannot deal with the gases in the available space of time.

He met a well-known metallurgist yesterday who said, "You go and see M. Ronceray's foundry, see his castings, see his cupola practice and see his results. I have been, and it is an education to any chemist or foundryman in this country."

Without any doubt whatsoever there is much in M. Ronceray's teachings which each of us, in our own way and to suit our own needs, can adopt or adapt with much profit to our work.

THE AUTHOR'S REPLY.

Replying first to Mr. Smalley, M. Ronceray said that undoubtedly the blow holes in the discs were caused by air being entrained with the metal and not by shrinkage holes, as suggested by Mr. Smalley. He himself had made similar castings, and they were all sound. The iron was poured as hot as possible, and the mould was poured on the incline, so that the first casting in the mould received hottest iron and the last casting received the coldest iron, and as a consequence the last casting was not sufficiently run, but at the same time it was quite sound. No evidence of shrinkage holes could be found anywhere.

He emphasised this point because he wanted to make it clear that he had made very small castings with the metal high in silicon and high in phosphorus, and moreover his mixture contained a large quantity of scrap iron. He had made the moulds in green sand, and under these conditions the escape of gas was much more difficult than in a dry-sand mould as made by Mr. Smalley, but all his castings were still sound.

He wished to emphasise that he had no other purpose in view than to help the foundry trade, but he was absolutely unable to make scientific experiments, as he had neither the time nor the equipment for that, but simply wanted to say to the scientific members of the Institution of British Foundrymen that he had made certain experiments and produced certain results, and he wished to put it up to them and to ask them to make research and to find the reason why these remarkable results had been obtained, which, after all, were generally contrary to accepted conditions.

Regarding the use of hot iron in the jobbing foundry, he pointed out that he did this every day without any difficulty whatsoever, and that there is no difficulty to be experienced in any jobbing foundry, or, for that matter, in any foundry, in getting really hot iron.

M. Ronceray said that he had not had any experience with regard to steel, but, judging from what Mr. Stobie had said, it seemed that steel was a very bad metal to deal with, although, of course, with iron they also had difficulty with slag inclusions, but not to the same extent, and, of course, they can dispose of them by proper means.

Slow Pouring.

M. Ronceray said that, if they would read the lecture which he had given in London, they would see that he had insisted upon slow pouring. If, by slow pouring, 10 per cent. of foundry wasters were done away with, then something had been gained. While making shells during the war, it was also found that to mix steel with iron helped to reduce porosity. This is one way to help, but another, and perhaps more important, is to take every precaution for the escape of gases, because very often shrinkage and porosity, which were at the present time attributed to metal causes, could be done away with by proper intelligent venting of moulds.

M. Ronceray also called attention to what Mr. Wilson had said in the discussion, and pointed out that Mr. Wilson's experiments had shown that the method of slow running and proper venting which he had asked Mr. Wilson to experiment upon was a step in the right direction, because Mr. Wilson was now getting ingot moulds much heavier than previously, which clearly showed that the previous moulds, which were fed with a very big feeding head, were not sound. Moreover, the venting of the mould in the way Mr. Ronceray had pointed out to Mr. Wilson had undoubtedly helped him to get good results.

In reply to Mr. Fryer, M. Ronceray said he thought, by putting the 6-in. runner direct on to the casting together with a filter core, it could be made solid. Porosity could be caused in the case indicated by Mr. Fryer through various reasons, one of these being the swelling of the mould. With a certain thickness of metal, say 3 in., there was no shrinkage at all—he was perfectly convinced of that. M. Ronceray believed the trouble could be attributed to sand causes mainly. In ordinary castings thicknesses, real shrinkage would very seldom be found, providing proper venting had been made; they had made castings somewhat of a similar nature and soundly.

However, it was very difficult to say what actually was the cause of the porosity without knowing all the circumstances; but, on the other hand, he was quite willing to make experiments, and try and solve the problem if Mr. Fryer would send him a blue print of the casting and a full and concise report on the difficulties which were encountered during the work. He felt sure he could overcome Mr. Fryer's trouble.

M. Ronceray here referred to the fact that he had answered Mr. Wise during his questions, and that he did not think anything else need be said about Mr. Wise's remarks, except that he contended that it was perfectly impossible to have a draw or segregations in sections of 1 in. thick, and that he must look some other way for the cause of his trouble, which was caused probably through an insufficiently dried core and through the gases escaping through the metal instead of through the sand.

The same remarks apply to the queries raised by Mr. Binns. M. Ronceray also referred to the reproach given to him that he had not given any explanation of the results obtained by him. Frankly, he believed that this did not matter much. He stated accomplished facts—the results of thought and experiments in his own foundries. He gave the conditions of his test, and he suggested that, whilst all practical men can repeat these facts, they could be considered somewhat extraordinary, and he thinks that, this being the case, something extraordinary having been accomplished, it is the duty of the scientific members to examine these things and explain these extraordinary circumstances. This is almost always the case in new discoveries, and the scientific man must investigate fully these problems.

The President, in proposing a hearty vote of thanks to M. Ronceray for his excellent lecture, said that he thought it was one of the most interesting Papers the Newcastle Branch had ever had. He thought that M. Ronceray's process would probably depend a great deal upon how the sand was prepared, and he regretted there was no time left for him to contribute to the discussion.

A very hearty vote of thanks was then accorded to M. Ronceray, to which he suitably responded, and the meeting was closed.

SHEFFIELD BRANCH.

At the February meeting Dr. Percy Longmuir, D.Met., Director of the British Cast Iron Research Association, repeated his lecture on "Notes on Iron, Steel and Brass Foundry Practice." This has already been published in our columns.

Dr. Longmuir, in the course of his lecture, said he would like to mention the very valuable work which was being done by Professor Ripper, of Sheffield University, in regard to the Trades Technical Societies. There were, he thought, about 14 of these societies in existence, and the last one was that known as the Foundry Trades Technical Society. Possibly no explanation was needed, but he would like to say most definitely as one of the founders of the Institution, and as one of its past-presidents, that there was not, and could not be, any rivalry between the Foundry Trades Technical Society and what was now known as the Institution of British Foundrymen. These societies were established to form a connecting link between the University and the particular industry on the one hand, and on the other hand between the societies and established professional associations or institutions like their own. The whole of the Trade Technical Societies simply served as feeding grounds for either the different technical institutions or the different professional technical societies. The British Cast Iron Research Association took a good deal of his time, and he would like to say a word in regard to it. He was not out for any ulterior motive, but he would like to put in a word in the hope that the Association through its various branches—and he had visited most of them during the past three or four months—would give it all the encouragement possible—sympathetic encouragement if they liked.

Discussion.

Dr. T. Swinden (Branch-President) said he welcomed Dr. Longmuir's statement about the Foundry Trades Technical Society, and they hoped it would achieve the objects which he had outlined —to improve the scope and encourage the work of the University classes, and what was of perhaps more interest to them, to increase the membership of the Sheffield Branch of the Institution and increase the interest in the Institution. He would like to refer to the work being done by the various research associations, and once again to emphasise the necessity of publishing the results of scientific work on more democratic lines, as was the custom in America. The sooner they adopted that method of encouraging work and publishing it all at a minimum cost, the sooner they would reap the benefit of the immense amount of research work which was being done to-day. Dr. Longmuir had dealt with a wide range of subjects, and he hoped there would be a full discussion on the many interesting points.

Graphite and Strength of C.J.

Mr. J. Shaw, in opening the discussion, stated he was quite in agreement as to the importance of low total carbon. It sounded to reason that if two irons both contained about 0.8 per cent. C.C., but one iron had a total carbon of 3.5 per cent. and the other a total carbon of only 2.8 per cent., that the latter was a much stronger iron, because it contained roughly 30 per cent. less of the weakening element, graphitic carbon. Also nearly always the graphitic carbon in the high carbon iron was in a more open form. It was held by at least two well-known metallurgists engaged in Diesel work that the finely distributed graphitic carbon found in low total carbon irons persisted on re-melting in the cupola. Dr. Longmuir had again shown them the results of his well-known research on casting temperatures. While accepting these results, it must at once be admitted that rarely was cupola metal so superheated as to lower any test result for an ordinary casting. It might often occur from cold metal. Even here he (Mr. Shaw) had come across a different result. During experiments with bars for the Test Bar Committee, it was found that casting temperature had no effect on round bars cast vertically in dry sand moulds, top poured. Several times over a number of bars cast from the same ladle, with a four minutes' interval between, until the last bar would only just run, showed little variation in the transverse test. These results were quite contrary to all past experience with bars cast either at an angle or flat. Whether it was due to the constant agitation caused by top pouring in a vertical mould or not that gave a solid bar, was an open question. The results had been tried by two other members with much the same result.

Mr. H. Bradley asked if Dr. Longmuir could state what he considered should be the proper temperature to pour steel for castings; could he say the best instrument or any other means of ascertaining the heat of the steel in the ladle before casting? He would also like to have some idea of the variation in steel castings as regards fettling. If, for example, two moulds were taken made from the same pattern, and the same mix of compo made by the same moulder, cast from different heats, but approximately the same temperature, one casting would be quite clean, while the other would be very rough. He would also be glad of any information in regard to the temperature of solidifying of the steel when a pull in the casting took place.

Mr. F. Kayser said that when such a wide range of subjects was introduced it was impossible to have a useful discussion. There was now a tendency for papers to range over a wide variety of subjects, and to the student there was sometimes a difficulty in following them. He thought it might be better to concentrate a little more on one particular point and not attack the whole subject. Dealing with the conduct of metals in the moulds, he thought the fluidity of all metals was very similar. If they took carbon steel or cast iron, it seemed to him that fluidity was very much the same.

Mr. H. Darley, dealing with refractory material, said he was very much interested in Dr. Longmuir's experience when casting a core about 4 in. dia. through the post of a large phosphor-bronze rudder. The core was struck up on a barrel covered with a straw band and loam, but Dr. Longmuir found when they came to remove the core that the metal had sweated through the refractory loam and straw band and filled the

barrel. After they had removed the core they found they could rub off the plumbago inside the hole with their fingers. This was quite opposite to his own experience with a similar job made in steel, where the core barrel was fused and the core was solid steel and sand, the barrel could not be got out whole. The only way to get it out was to burn it out by means of an electric carbon arc. He did not think it was possible to make a core, say, as small as 4 in. dia. that would stand up to 5 or 6 in. of fluid steel. He would be pleased if Dr. Longmuir could tell him to what extent the so-called impurities (say sulphur and phosphorus) affected the fluidity of the steel. Taking an electric furnace where they frequently obtained an analysis of C. 0.22 to 0.24, Si 0.30 to 0.35, Mn 0.60 to 0.70, S 0.013, and P 0.012, unless the metal was very hot it lost its fluidity very quickly, and was not satisfactory for steel castings which required to be machined, as they immediately found small gas holes chiefly in the bottom side of the casting. His opinion was that if they increased the sulphur from 0.013 to 0.04, and the phosphorus from 0.012 to 0.06, they got a much more fluid steel, and therefore a more satisfactory casting.

Nickel-Chrome Alloys.

MR. A. RHYDDERCH said Dr. Longmuir had dealt with many points connected with foundry practice, amongst which was the question of permanent moulds. A great deal of work and progress had been made in that direction, lately in connection with nickel-chrome alloys as used in centrifugal casting machines, and also the use of precipitated surface film of various oxides and alloys. The action in each case was the same, namely, the deposit of an emulsified oxide skin which was extremely refractory. Probably more would be done in the future in the direction with nickel-chrome alloys. The lecturer had referred to the searching power of various metals and alloys. Of course this was related to temperature, and the resultant fluidity and also the degree of fineness or coarseness of the sand used. Another fact was the state of the metal as cast—whether or not it had been well-melted. It was extremely difficult to conceive the instance given where the "eutectic" had penetrated to the core yet the skin was good. A few more details regarding temperature of casting, composition of metal and the eutectic, and the fineness of the sand would be interesting. Certainly, as far as steel was concerned, when the metal did penetrate the core the whole mass was vitrified and semi-fused. There was certainly no skin or paint left on the casting. In a few cores the penetration had been due to extreme coarseness and an insufficiency of bond, thereby yielding a friable skin which broke down and disintegrated on erosion. It had to be remembered that large cores were made up of coarse material bonded with clay—only sufficient clay was added to give the bond and yet leave the core permeable. In the case of rough material that was difficult to do and the result was often a breaking into the core. An interesting point was that the first 2½ to 3 in. of such a penetrated core frequently contained as much as 20 per cent. of metal. It had often been mentioned that a sand or compo was "too refractory." Had the lecturer come across any such instances? The skinning of castings and the searching power of Tropena steel had been mentioned. Was this not connected with very high casting temperature—somewhere between 1,670-1,690 deg. C.—which was a higher temperature than that produced by any other process?

A New Sand-Mould Facing Suggested.

The composition of the steel had a great deal to do with the stripping of castings, as well as the composition of the sand. For instance, manganese steel left a sand mould almost as clean as an ingot form and ingot mould. An examination of the sand revealed a greenish mass—a silicate of iron and manganese which had no adherence to the steel. The obvious conclusion was whether a surface coating of a manganese oxide or salt or even alloy would bring about the same effect in an ordinary carbon steel. Exactly the form in which it should be used was a matter for experiment. Another point of interest on stripping was the fact that the yellow sands stripped better than red sands, and red better than synthetic mixtures. These yellow sands—Belgian and South Cave—contained a mineral called glauconite; in fact, it could be picked out in lumps from the Belgian sands. In the sand it was very fusible and very plastic. No trace was found in the red sands; in fact, the red sands could be produced by heating the yellow sands to about 500 deg. C. in an oxidising atmosphere. It was therefore quite probable that the superior stripping power of the Belgian sands was due to the presence of the mineral. A great advance would have been made when the stripping of castings could be satisfactorily explained.

Electric Furnace Roofs.

In regard to refractories, wrong selection and ignorance of conditions were often the cause of troubles in furnaces. A coke-oven silica-brick was totally unsuited for the roof of an electric furnace. As an instance of the value of correct selection, he might mention that an electric furnace roof lasted 80 heats with one brick, whereas another brick—used under the same conditions as nearly as was possible in works practice—gave 140 heats. A great deal of work had been done on the testing of refractories, but very much more remained to be done. The methods of testing had been fixed, and very valuable results published, but the correlation of the efficiency of a brick in practice with laboratory tests was in a very infantile state. In fact, the works test was the only one of value. In regard to the utility of tests as control, it appeared as if the density total content of silica, texture and the amount of converted quartz were the easiest and probably the most useful tests. Insufficient attention was paid to texture, which had a very great bearing on the value of a brick.

Perhaps the most important part of the lecture was that of casting temperature, and some of the results quoted were familiar to all. They simply showed how difficult it was for a poorly-equipped foundry to meet high specifications unless they had good temperature measurement methods. One further point appealed to him, and that was in connection with the annealed steel castings. When a difference in casting temperature did not have a very appreciable effect on the tensile strength, yet the elongation was very considerably altered. In fact, he believed the difference was of the order of 300 per cent. It would be interesting to have a few micro photographs of those samples. Probably it was simply a question of grain size and structure.

The Author's Reply.

In a brief reply, DR. LONGMUIR said that, generally speaking, in all good foundry practice it should be melt hot, melt quick and cast quick. Mr. Shaw had raised the point of vertical casting, and he hoped some day in the near future to experiment on this. He had made one very good remark which was applicable to every class of foundry practice—no hard and fast rules could be made. He had tried to show the breadth, and he hoped the extent, of the "variables" which entered into foundry practice. He thought during the course of his remarks that he had made it quite clear there could be no best temperature for any given alloy. It must of necessity vary with the mould and the skin of that mould. What might be ideal in the case of a 3-ft. cube would not be ideal for the metal or alloy in the case of the 3-ft. plate ¼ or ½ in. thick. He would require a further half hour to deal with the point raised. In regard to fluidity, some metals had apparently a greater running power than other metals. It was the fluidity that made cast iron the valuable metal it was.

Institution of Welding Engineers.

An Institution of Welding Engineers has been formed.

The first president is Sir W. Peter Rylands, and the vice-presidents are Sir Robert A. Hadfield, Prof. F. C. Thompson and Charles Bingham, C.E.

Included in the first council are representatives of every section of the welding and allied industries—electric, oxy-acetylene, thermit welding, etc., and materials—acetylene, carbide, oxygen, electrodes, etc., used in the industry.

Full particulars and application forms can be obtained on application to Mr. C. Raggett, 30, Red Lion Square, London, W.C.1.

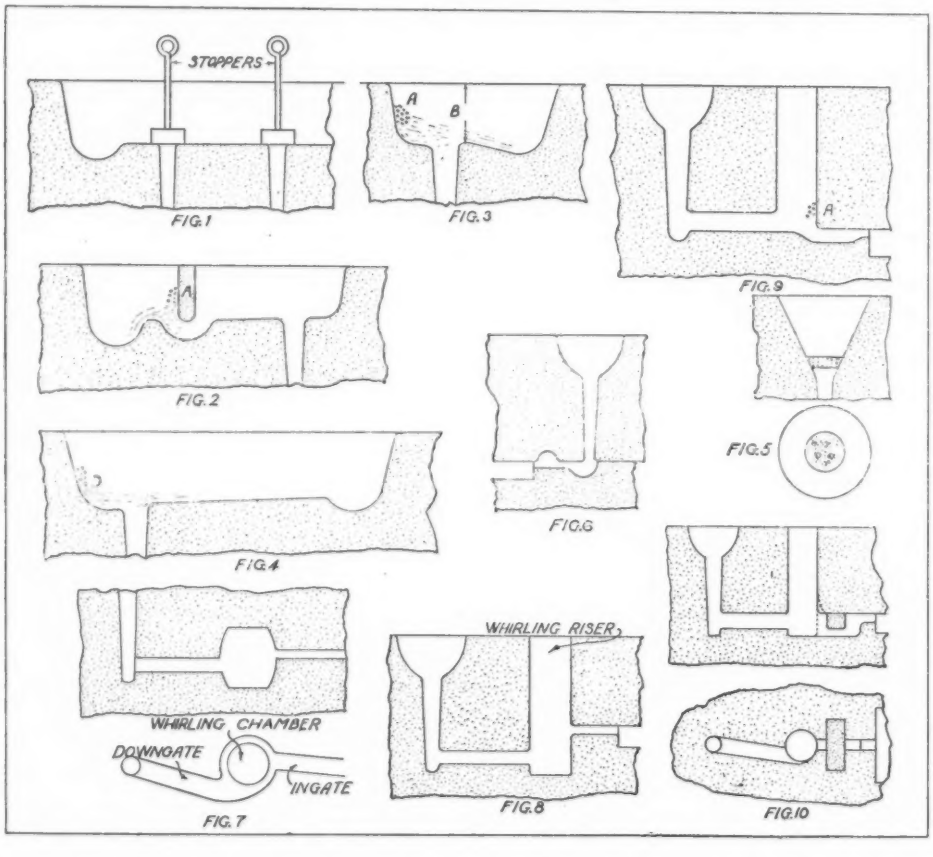
XUM

An Apprenticeship Course in Foundry Practice.—XL.

By Ben Shaw and James Edgar.

RUNNERS, RISERS AND HEADS.

The manner in which a mould is supplied with metal has a considerable influence on the character and quality of the resulting casting, so much so that a large proportion of the many inferior and bad castings are a direct result of unsuitable and badly-placed runners. However carefully a mould may be prepared, the running of the metal is largely responsible for the quality of the casting, and, although much time may have been spent in its preparation, the resulting casting may be a waster owing to the use of faulty or carelessly prepared runners. The influence of proper gating on the production of sound casting is such that the apprentice should have well-defined ideas of the principles involved in the different forms of running in order that he will be able to apply similar principles intelligently for a wide variety of work.



Probably the most important consideration for ensuring sound castings is the design of the pouring basin and gate. These should be so formed that only clean metal enters the mould. It is carelessness in this respect that causes many wasters. Careful skimming will prevent much dirt and scum from passing into the pouring basin, but invariably some does pass, and, unless means are taken to prevent this dross from entering the mould, a bad casting is likely to result. Any slag or dirt that does pass must occupy some place. As it is lighter than the metal it may float on the surface and rise with the metal in the mould, or, if the metal lacks fluidity, it may be held in suspension, or it may become attached to the mould, either lodging against a projecting part as the metal rises, or be thrust against the mould by an eddy caused by the flow of metal. In some cases it is possible that any scum entering the mould may rise with the metal and enter a judiciously-placed riser, but there is no guarantee that this will happen, and, therefore, the possibility of a sound casting resulting, when slag or dirt has entered with the metal, is more or less left to chance. Pouring basins and gates should therefore be primarily designed to allow only clean metal to enter the mould.

Character of Metal Important.

The character and condition of the metal to be cast are also important factors, and these must be considered when preparing suitable facilities for the entrance of the metal into moulds. Different metals and alloys vary in their degree of fluidity, and the area of entry should be sufficiently large to ensure that the mould will be filled. Thus, the runners for gray-iron castings need not be so large as those necessary for similar work in steel or brass. Grey iron retains its fluidity better, and it is comparatively "thin" in a liquid state, whereas molten brass or steel are "thick" and sluggish. The temperature of a metal or alloy above its melting point determines its degree of fluidity, and when it appears lively and fluid it is referred to as a "hot" metal, a lazy, sluggish metal being "cold" in comparison.

The design of the required casting and its thickness of metal influence the method of pouring and the size of the runners. The thinner the metal sections and the more complicated the casting the hotter and, consequently, the more fluid the metal must be, and greater care is necessary to ensure that the mould is filled rapidly enough to prevent the possibility of cold-shuts being formed. Castings of unequal thickness require to be run to suit the thinnest parts. The kind of metal to be used must be associated with the design of the work in determining whether it should enter the mould

directly or indirectly, whether at the top or bottom or a combination of top and bottom pouring.

In all forms of pouring it is desirable to distribute the metal throughout the mould as evenly as possible and in such a manner that the reduction in temperature is regular in order that the metal will sondify regularly and thus distribute the strains due to shrinkage and contraction.

Runner Basins.

The special function of the runner basin is to act as a receiver or funnel to prevent the splashing of metal by giving a larger pouring area, and to maintain a head of metal from which the downgate is supplied. It also acts as a distribution chamber when many downgates connect it with the mould. Every effort should be made to prevent scum and dirt entering the gate, and the basin should be designed to reduce this possibility. A very common form of runner basin used for large work, especially when many downgates connect it with the mould, is shown in Fig. 1. In this method advantage is taken of the fact that all forms of dross in the metal rise to the surface, and by covering the downgates metal can be prevented from entering the mould until the runner basin is practically full. Flat cast-iron stoppers are used for covering the gates, lifters being cast in them as shown in the sketch. They should be dipped in blackwash and dried before being used. When the runner basin is filled with metal the stoppers may be lifted simultaneously or according to the requirements of the work, and, as long as the basin is kept full, slag and dirt will rise to the surface and the cleaner metal pass down the gates. This method is useful for plain cylindrical work cast on end. In some instances the method is extended somewhat and the basin is made large enough to hold all the metal required for the job, and the stopper is not lifted until the basin contains the requisite amount of metal. Other variations of this method consist mainly of a receiver basin, containing the full amount of metal, and a secondary basin which acts as a distributor, the main idea being to cause the scum to rise to the surface and to provide clean metal from the bottom for the mould.

Skimming Basins.

When the downgate is left open at the time of pouring some means must be taken to trap the dross which passes from the ladle or crucible. In many cases skimming basins are used for this purpose, an example of which is shown in Fig. 2. In this instance the basin is prepared to receive a slab core at A under which the metal must pass. The end of the basin which receives the metal is depressed to act as a cushion for subsequent metal and also to prevent splashes passing the skimmer at the beginning of the pouring and entering the gate. To obtain full advantage from a skimming basin such as this it is necessary to supply the first metal quickly in order that the skimmer may be effective. This is equally necessary in all forms of basins that have their gates uncovered in order that a head of metal will be quickly formed so enabling scum to rise and clean metal to enter the mould. The skimmer in this case traps dross in the manner shown in the illustration and allows more or less clean metal to pass under it to the gate.

With ordinary pouring basins the design has considerable influence in preventing dross entering with the metal. Two examples as shown in Figs. 3 and 4. That represented in Fig. 3 is a type used for smaller work. It should be recessed deeper where the metal is to be poured and inclined so that splashes of metal and dross will be carried to A, as shown, by subsequent metal. The basin at A should not be directly above the gate, otherwise more dross is likely to enter with the metal. The depth of the basin at B should be sufficient to reduce the agitation of the metal entering and to allow dross to rise. For larger work the type illustrated by Fig. 4 is more frequently used. Some prefer to use the same principle as that involved in the previous example, and there is much to be said for it, providing the depth at B is maintained to accomodate a quantity of metal that will have little influence in drawing the dross from its surface as it enters the mould. Others believe that better results are obtained by making a slight gradient towards the gate to quicken the progress of the metal and to reduce possible cutting action. This latter method does not prevent dross entering the gate at the beginning, although this difficulty can be practically overcome by making the basin deeper at D. This causes the top of the first metal to pass over the gate, and dross is forced towards the end of the basin as shown in Fig. 4. With the ordinary funnel-shaped runner basin some special means must be taken to prevent dross entering with the metal, or some form of skimming gate will be necessary to clarify the metal before it enters the mould. This can best be accomplished by the use of a filter or strainer (Fig. 5), either in the form of a perforated core or a thin metal plate having a number of holes through it. In this method also dross is likely to pass the filter at the commencement of the pouring, but, if the strainer is covered with paper, the funnel-shaped basin can be filled with metal before an entrance is effected, and the strainer will hold up dross subsequently. Prepared as a core the strainer is more suitable for general purposes, though not necessarily more successful than thin sheet metal; with the latter, however, it is necessary to vary the strainer to suit the metal to be cast. Thus sheet iron is suitable for all kinds of cast iron while sheet copper is used for non-ferrous alloys.

Skimming Gates.

As a double precaution against the introduction of dross with the metal some effort is frequently made to skim or trap it should it enter the gate. No pains should be spared to ensure that the mould is filled with clean metal. When no special precaution is taken in the formation of the runner basin, then it becomes necessary to prepare some suitable trap in the gate. A simple example of such a trap is shown in Fig. 6, which is frequently used for small work. By removing sand from the top side of the ingate, in the manner shown, dross is likely to lodge in it, but it is, of course, necessary to keep the funnel-shaped basin full of metal. A very successful dirt-catcher is the whirl gate, of which there are many forms. In this method advantage is taken of the fact that when a liquid is forced to circulate in a circular chamber anything that floats in it will be drawn to its centre. Thus if metal is supplied tangentially to a circular chamber, in order to cause it to revolve dross will collect at the centre and clean metal will be drawn from the outside in the manner shown in Fig. 7. This method can be extended and a substantial riser used in which the dross can rise, as in Fig. 8. The connection between the downgate and the whirling riser should be larger in area than that which supplies metal to the mould, so that metal will fill the riser and attract dross to its surface. Instead of the whirling riser the ingate may be formed to provide a trap for dross, as at A in Fig. 9. In this instance also the riser is larger than the downgate, and the area of the connection to the riser greater than the spray to the mould. The special advantage of this type is that the trap at A receives the first metal, and subsequent metal is likely to force it into the riser, giving a head of metal to which dross will be attracted and allowing comparatively clean metal to enter the mould.

A more elaborate form of skimmer is that which consists of a combination of these last two types. Both a whirling riser and trap are introduced, as shown in Fig. 10. In this case it is more profitable to use a core for the trap in a somewhat similar manner as for the runner basin previously referred to. These are effectively employed for light work when it is convenient to form a pattern, with prints for the core, so that it can be located against the work and rammed up in the drag by means of the turnover method.

(To be continued.)

JOHN GRUNDY, LIMITED, of Tyldesley, and 393a, City Road, E.C.1, have installed their "Hestia" system of core and mould drying at the Atlas Works, Burnley, of James Pollard, Limited.

Trade Talk.

The report has been issued of the work of the Conjoint Board of Scientific Societies during the years 1916 to 1922 inclusive.

Recently another blast furnace was put into operation at the works of the United Steel Companies, Limited, at Oldside, Workington.

The Old Hill (Staffs.) furnaces belonging to N. Hingley & Sons, Limited, of Netherton, have been restarted after being inoperative for about two years.

A fire broke out on April 13 at the works of Howell & Company, Limited, steel manufacturers, Brook Lane, Sheffield, but the damage was only slight.

T. G. Murray & Company, Limited, engineers' merchants, have removed from 120, The Albany, Old Hall Street, to 218, Royal Liver Buildings, Liverpool.

W. Doman & Company, engineers, of Finsbury Court, Finsbury Pavement, London, E.C.2, have been appointed agents for N. V. Ijzer-en Staalhandel Anton A. Northier, iron and steel merchants, Kortenaerstraat 11b, Rotterdam.

The Dorman wave power tools will be demonstrated at the Sixth International Mining Exhibition in June, the Engineering, Shipping and Machinery Exhibition in September, and the Public Works, Road and Transport Exhibition in November.

Christmas & Walters, Limited, of Caxton House, Westminster, S.W.1, have received orders for three different installations of R. D. Wood automatic gas machines during the last few weeks. They have also received various orders for Lake patent gas reversing valves.

The business of Hoffman's, steel and ball-bearing manufacturers, Chelmsford, has been disposed of by the Government, as a going concern, to the Parent Tyre Company and the United Steel Companies, Limited. The business was taken over by the Government during the war.

Five vessels of 6,860 total net register tons were launched in the Tyne in March, as against five vessels and 19,345 tons in March last year. From January 1 to March 31, this year, 13 vessels of 26,534 total tons were put into the water, as against 11 vessels and 42,235 tons in the first quarter of last year.

Members of the Amalgamated Engineering Union throughout the West Riding of Yorkshire have put in a claim for an increase in wages which will bring the standard rate for the district up to £3 6s. for a 47-hour week. This means an average increase of 11s. a week for Leeds and Bradford, and 12s. per week for Huddersfield, Halifax, Wakefield and York.

An Association of large users of brass and copper (sheet and strip) has been formed to secure mutual co-operation and to promote the welfare and interests of members in relation to supplies of sheet and strip brass and copper. Manufacturers using 140 tons per annum, or more, are eligible for membership. The secretary is Mr. P. P. Richards, Box 18, Chamber of Commerce Buildings, Birmingham.

The Whitworth Society has been formed as an association for Whitworth scholars, exhibitioners and prizemen, with a temporary home at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. The hon. sec. is Mr. E. R. Dolby, and the hon. treasurer Prof. D. A. Low. The preliminary dinner is to take place on Tuesday, September 11, at the Shipping, Engineering and Machinery Exhibition, Olympia, London, where the members will be received by the chairman of the Society, Dr. F. S. Hele-Shaw, who is also chairman of the Committee of Experts of the Exhibition.

Obituary.

Mr. F. E. Brown, of John Brown & Company, engineers, Greenwich, S.E.10, died recently.

Mr. G. F. L. Foulger, formerly chief distributing engineer to the Gas Light & Coke Company, died recently. He retired in 1909.

Sir Albert John Hobson, one of the leading steel manufacturers in this country, and a financial and industrial authority of international reputation, died on Friday at Sheffield.

Mr. William Muirhead, of William Muirhead, Limited, Mount Vernon Iron & Steel Works, Shettleston, Glasgow, died last week at the age of 69. Mr. Muirhead spent his whole life in the industry, his first important appointment being that of chief metallurgist with William Beardmore & Company, Limited, Parkhead. He was largely instrumental in laying down and starting the works of the Lanarkshire Steel Company, Limited, at Flemington, and acted as manager for some time afterwards. On leaving this company he began business on his own account in Glasgow, and his researches culminated in the introduction of a metal now known as the Muirhead metal.

Company News.

Protector Foundry, Limited, Tipton.—Capital £100 in £1 shares.

P. Ormiston & Sons, Limited, 79, Clerkenwell Road, London, E.C.—Capital £5,000 in £1 shares. Wire drawers.

Approved Engineering Company, Limited, East Street Works, East Street, Coventry.—Capital £1,000 in £1 shares.

Hargreaves, Hammond & Company, Limited, Silverwell Lane, Bolton.—Capital £10,000 in £1 shares. Engineers.

Adye & Company, Limited, 50, Lincoln's Inn Fields, London, W.C.—Capital £7,500 in £1 shares. Machinery manufacturers.

Robert Potter & Sons, Limited, 50, Helen Street, Govan, Glasgow.—Capital £75,000 in £1 shares. Ironfounders, engineers, etc.

George Tucker & Company (Sheffield), Limited, 51, Norfolk Street, Sheffield.—Capital £10,000 in £1 shares. Metal merchants.

Orion Engineering Company, Limited, Standard Buildings, Park Road, Leeds.—Capital £10,000 in £1 shares (6,000 preference and 4,000 ordinary).

Dearie & McKean, Limited, Devon Buildings, James Street, Cardiff.—Capital £1,000 in £1 shares (900 preference and 100 ordinary). Engineers' agents.

Manganese Bronze & Brass Company, Limited.—Brought forward, £17,986; profit, £21,887; preference dividend for year, £10,125; carry forward, £11,761.

Babcock & Wilcox, Limited.—Dividend, 9 per cent. for half-year, together with bonus 3 per cent., both free of tax, making, with interim, 20 per cent. for year.

Bede Metal & Chemical Company, Limited.—Loss, £13,520; debit balance brought forward, £42,661; less reserve fund written off, £27,000; debit of profit and loss account, £29,182.

Rudge Brothers, Limited.—Capital £3,000 in £1 shares, to take over the business of general brassfounders, manufacturers, stampers and piercers, carried on by W. H. Rudge and H. T. Rudge at 31, Fleet Street, Birmingham, as Rudge Brothers.

Hadfields, Limited.—£1,000,000 7½ per cent. mortgage debenture stock redeemed, and £1,040,000 5½ per cent. mortgage debenture stock to be issued; investments written down to present-day values by transfer of £137,000 from special reserve account; profit, £187,250; brought forward, £122,657; total, £309,907; further dividend 6d. per share, making 5 per cent., tax free; carried forward, £128,418.

Personal.

Mr. T. B. Bentley, of Victoria Road, Great Crosby, Lancs., and of Liverpool, iron and steel agent, left £9,563.

Mr. C. Bright has been elected a London director of Muntz's Metal Company, Limited, of French Walls, Birmingham, and 126, Bishopsgate, London, E.C.2.

Mr. H. Brearley, a director of Brown Bayley's Steel Works, Limited, and the Firth-Brearley Stainless Steel Syndicate, Limited, Sheffield, is paying a business visit to South Africa.

Mr. E. A. Johnson, who for many years has been associated with W. B. George & Company, metal merchants, etc., 5, Fenchurch Street, London, E.C.3, has been taken into partnership.

Mr. W. T. Evans, president of the East Midlands Branch of the Institution of British Foundrymen, has been appointed foundry superintendent to Ley's Malleable Casting Company, Limited, Vulcan Iron Works, Osmaston Road, Derby.

Mr. Ambrose Firth, late of the Knoll, Bamford, Derbyshire, and of Oban Road, Bournemouth, ironmaster, chairman of the Brightside Foundry and Engineering Company, Limited, Sheffield, and a director of William Cooke & Company, Limited, left £36,077.

Suggested Anglo-American Steel Agreement.—A cable from New York states that Mr. Charles Schwab, addressing the British Chamber of Commerce in that city, advocated an agreement between the steel manufacturers of Great Britain, France and the United States to end destructive competition in foreign markets. While German efficiency had apparently been destroyed for a while, German industry would eventually re-enter the foreign steel markets with ruinous competition unless there was an agreement for the most economical distribution of the steel business.

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.

THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS (MANCHESTER), LIMITED.

BLACKFRIARS, MANCHESTER.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Conditions in the Cleveland iron markets continue quiet, with very little fresh business passing either on home or export account, smelters, as a rule, having already booked commitments for outputs over the end of the current quarter, while consumers, on the other hand, restrict buying within the limits of immediate requirements. Some improvement in the Continental fuel position of late has enabled the Belgian and French blast-furnaces to get going again, with the result that there is no longer the same active inquiry for British iron, particularly now that the prices are so high. The possibility, however, of some reduction in rail transport charges, and hopes of decreased fuel costs, should certainly open up a prospect of lower pig-iron prices in the near future. Even now No. 3 foundry iron is lower at 125s., but this is a high figure from the home consumer's point of view, and has completely falsified the confident expectations formed at the beginning of the year. Prices at this week's market were somewhat under the previously quoted level, as follows: No. 1, 130s.; No. 3 G.M.B., 125s.; No. 4 foundry, 122s. 6d.; No. 4 forge, 117s. 6d. per ton.

The demand for hematite is distinctly quieter and on the export side is due to the same causes which operate in the case of foundry iron. But makers are comfortably situated, and there is only slight weakness in values. For June delivery, East Coast mixed numbers are round 122s. 6d., and West Coast Bessemer mixed numbers are unchanged at 137s. 6d. per ton delivered Glasgow/Sheffield, and round 140s. f.o.b. Liverpool.

MANCHESTER.—Buying in the local pig-iron market is still on a restricted scale, foundrymen in this area being reluctant to come forward until some modification of the high prices now current can be secured.

THE MIDLANDS.—Some increase in production may be noted as a satisfactory feature of conditions in the South Staffordshire area, one furnace having been re-lighted recently, and it is reported that other plants are ready for blast as soon as fuel supplies can be obtained on more favourable terms. Pending a further extension of output facilities, consumers of pig-iron in the district are holding off the market and are by no means keen to accept offers on forward account, fearing that a change in the Continental political situation may completely upset present conditions in the home trade.

SCOTLAND.—Although little fresh business is reported in Glasgow market, pig-iron deliveries are going forward against existing contracts, which will mostly extend over the remainder of the quarter. Makers' prices are unchanged at £6 at the furnaces, and £6 5s., f.a.s. Glasgow, and although ore is possibly a shade easier there is no relief in other costs, and smelters cannot, therefore, afford to reduce prices. Merchant holders, however, are prepared to cut the makers' prices by 1s. to 2s., but there does not seem to be much iron held in second-hands. Scottish founders generally report a dearth of orders, and this applies especially to the engineering branch. On the other hand, the light castings people are fairly busy, but what pig-iron buying there is is only for early requirements.

Finished Iron.

The manufacturing branches of the iron trade continue well employed, best bar makers, especially, having fairly substantial contracts in hand, which will keep works busy for some time to come. The increase in marked bars recently announced was scarcely expected, seeing that only about a month had elapsed since the previous advance, but when the whole position is considered it is not really surprising. Costs must have gone up considerably more than the former 10s. increase covered, and no doubt the makers are having to come on to the market again for raw materials, and are finding these a very different proposition from what they were at the beginning of the year. Encouraging reports are still heard concerning the best makes of crown bars. Producers readily dispose of all the iron made in their mills. There is also a hardening tendency about commoner bars, Lancashire nut and bolt iron, for instance, having been advanced to £11 17s. 6d., while Staffordshire makes are touching £11 15s. Offers of Belgian bars are still reported, but the terms, both as to price and delivery, are not now very attractive.

Steel.

With some few exceptions, all departments of the steel trade are fairly well employed on home and overseas contracts, the compulsory closing down of the principal Continental works having transferred a considerable proportion of orders to this country. In the market for semi-products, the buying of basic billets continues on a big scale, and makers of acid material are also busy. The output of open-hearth steel is the chief feature of production, but crucible steel is disappointing, though some manufacturers are rather better booked. Much of the business in mild steel is on foreign account. There is a very gratifying demand for railway steel, heavy quantities of which are on order. Electric steel is slowing down, and many of the furnaces are nothing like fully employed.

Scrap.

Little improvement can be reported in scrap metal movements during the current week, demand being on a more restricted scale, without, however, any noteworthy weakening of quotations for the leading qualities. A number of parcels of scrap, it is said, are now being offered from the Continent, and even further afield. As a rule, the prices asked are too high, but the fact that offers are being made shows that outlets are not being so readily found, and it may not be long before it will be possible to bring in material from outside sources at profitable prices. This will augment supplies considerably, and if any quantities are delivered a reduction in price can be confidently anticipated.

Metals.

Copper.—Business in the standard market, on the whole, has been quiet but steady, fluctuations in value having been confined within narrow limits, and buying chiefly restricted to home consumers. There is apparently a fair supply of second-hand metal waiting for disposal, and can be secured at well below the terms quoted by American first-hand sellers, who seem content to look on pending the advent of fresh American buying. Offers in near positions have been comparatively light just lately, while the great bulk of the business consisted of three months' warrants. The "bear" account has doubtless undergone some expansion, and repurchases may eventually lead to a recovery unless American producers make concessions. Current quotations:—*Cash*: Wednesday, £73 10s.; Thursday, £73 10s.; Friday, £73; Monday, £72 17s. 6d.; Tuesday, £72 5s. *Three Months*: Wednesday, £74 7s. 6d.; Thursday, £74 7s. 6d.; Friday, £73 17s. 6d.; Monday, £73 15s.; Tuesday, £73.

Tin.—The market for standard tin during the past week has developed an irregular tendency, with values continuing steadily on the down grade. There is now not much doubt that the prospective dispersal of the Eastern "pool" holdings has made its worst influence felt, while it is generally assumed that the gradual disposal of the controlled tin, as officially intimated, will in the long run help in strengthening confidence in the future of the metal. At any rate, an element of uncertainty has been to all intents and purposes removed, after having overshadowed the market for well over a year past. It is officially reported from Kuala Lumpur that 2,704 tons of tin were exported from the Federated Malay States during the month of March, as compared with 3,020 tons in February and 2,839 tons in the corresponding month of last year. The total export for the three months of the current year is 8,912 tons, as against 8,554 tons last year and 8,599 tons in 1921. Current quotations:—*Cash*: Wednesday, £209 5s.; Thursday, £208 15s.; Friday, £207 15s.; Monday, £212 15s.; Tuesday, £215 15s. *Three Months*: Wednesday, £209 15s.; Thursday, £209; Friday, £208; Monday, £212 15s.; Tuesday, £215 15s.

Spelter.—There is very little change in the general situation. Rudolf Wolff & Company report that the easier tendency is due to continued poor demand both here and on the Continent, as a result of which stocks are likely to accumulate. The market in America remains firm, but for the time being has no particular bearing on the London Market. Current quotations:—*Ordinary*: Wednesday, £33 17s. 6d.; Thursday, £34 5s.; Friday, £34; Monday, £33 17s. 6d.; Tuesday, £33 12s. 6d.

Lead.—The market for soft foreign pig has followed the general market tendency and wears a dull and uninteresting appearance. There is no inducement for consumers to buy pending the threat of a building strike and uncertainty as to future housing policy. Should demand in America ease off, it seems unlikely that the London price would be maintained, as at the present time its strength is due mainly to the possibility of shipping metal from Europe to America. Current quotations:—*Soft foreign (prompt)*: Wednesday, £26 10s; Thursday, £26 12s. 6d.; Friday, £26 5s.; Monday, £26; Tuesday, £26 5s.

XUM

Telephone: 21, Penistone. Telegrams: "Durranns, Penistone."

ESTABLISHED 1863.

JAS. DURRANS & SONS., LTD.

Phoenix Works, Penistone NEAR SHEFFIELD.

BLACKING
PLUMBAGO
CORE GUM
WHITE DUST
COAL DUST

Manufacturers of

FOUNDRY EQUIPMENTS.

Ladles, Cupolas, Fire Bricks, Ganister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

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SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

SPECIAL STEEL FOR CONSTRUCTIVE PURPOSES.

The STEEL COMPANY OF SCOTLAND, Ltd.

Head Office: 23, ROYAL EXCHANGE SQUARE, GLASGOW.
Works: HALLSIDE, NEWTON and BLOCHAIRN, GLASGOW.

CONTRACTORS TO HOME, COLONIAL AND FOREIGN GOVERNMENTS.

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GANISTER, CUPOLA BLOCKS, FIRE BRICKS, FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR, nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash ..	72	5	0
Three months ..	73	0	0
Electrolytic	80	15	0
Tough	76	10	0
Best selected	76	10	0
Sheets	106	0	0
India	93	0	0
Wire bars	81	5	0
Do. May	81	5	0
Do. June	81	5	0
Ingot bars	81	5	0
H.C. wire rods ..	86	0	0
Off. aver., cash, Mar.	73	18	4
Do. 3 mths., Mar.	74	12	2½
Do. Settlement Mar.	73	18	1½
Do. Electro, Mar.	81	14	7½
Do. B.S., Mar. ..	77	7	9½
Aver. spot price, copper, Mar. ..	73	17	3¾
Do. Electro, Mar.	82	0	0

Solid drawn tubes 14¾d.
Brazed tubes .. .. 14¾d.
Wire .. .. .. 11¼d.
Yellow metal rods .. 7½d.
Do. 4x4 Squares .. 9d.
Do. 4x3 Sheets .. 10d.

BRASS.

Solid drawn tubes .. 13d.
Brazed tubes .. .. 14¼d.
Rods, drawn .. .. 11¼d.
Rods, extruded or rolled 7½d.
Sheets to 10 w.g. .. 11d.
Wire .. .. .. 11d.
Rolled metal .. .. 10½d.

TIN.

	£	s.	d.
Standard cash ..	215	15	0
Three months ..	215	15	0
English	216	0	0
Bars	218	0	0
Chinese	215	0	0
Straits	222	15	0
Australian	220	0	0
Eastern	220	5	0
Banca	219	5	0
Off. aver., cash, Mar.	219	15	0
Do. 3 mths., Mar.	220	18	10⅝
Do. Sttlment, Mar,	219	15	0⅜
Aver., spot, Mar. ..	219	13	4

SPELTER.

	£	s.	d.
Ordinary	33	12	6
Remelted	31	10	0
Hard	28	0	0
Electro 99.9	40	0	0
English	34	7	6
India	29	0	0
Prime Western ..	34	5	0
Zinc dust	49	0	0
Zinc ashes	13	0	0
Off. aver., Mar. ..	36	15	4⅞
Aver., spot, Mar. ..	36	14	4½

LEAD.

	£	s.	d.
Soft foreign ppt ..	26	5	0
English	27	10	0
Off. average, Mar.	28	15	1¼
Average, spot, Mar.	28	16	3¾

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	43	0	0
Do. V.M. ex whf.	42	0	0
Dutch	42	0	0
Rods	50	0	0
Boiler plates	41	0	0
Battery plates ..	42	0	0

ANTIMONY.

	£	s.	d.
English regulus ..	30	10	0
Special brands ..	36	15	0
Chinese	27	10	0
Crude	20	0	0

QUICKSILVER.

Quicksilver 9 15 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—
45/50% £13 2 6
75% £20 17 6
Ferro-vanadium—
35/40% 16/9 lb. va.
Ferro-molybdenum—
70/75% c. free 9/6 lb. mo.
Ferro titanium—
23/25%, carbonless 1/2½ lb.
Ferro-phosphorus, 20/23%, £27
Ferro-tungsten—
80/85%, carbon free 1/5½ lb.
Tungsten metal powder—
98/99% .. .. 1/10½ lb.
Ferro-chrome—
4/6% car. £23 10
6/8% car. £22 10
8/10% car. .. £21 10
Ferro-chrome—
Max. 2% car. .. £52 0
Max. 1% car. .. £62 0
Max. 0.70% car. £72 0
67/70%, carbonless 1/6½ lb.
Nickel—99%, cubes or pellets .. £130 0
Cobalt metal—98/99% 12/- lb.
Aluminium—98/99% £110
Metallic Chromium—
96/98% .. .. 4/6 lb.
Ferro-manganese (net)—
76/80%, loose .. £18
76/80%, packed .. £19
76/80%, export .. £18
Metallic manganese—
94/96%, carbonless 2/- lb.
Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, tungsten .. .. .. 14% s. 2 d. 6
Finished bars, tungsten 18% 3 0
Per lb. net, d/d buyers' works.

Extras—
Rounds and squares 3 in. to 8 in. inclusive 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Flats under 1 in. by ⅛ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness .. .. 3d. lb.
Bevels of approved sizes and sections .. 6d. lb.
If in coils .. .. .. 3d. lb.
Bars cut to length 10% extra

Scrap from high-speed tool steel—
Scrap pieces .. .. 3d.
Turnings and swarf .. 1d.
Per lb. net, d/d steel makers' works.

SCRAP.

	£ s. d.	£ s. d.
South Wales—		
Heavy steel	5 5 0	5 10 0
Bundled steel & shrngs.	4 12 6	5 5 0
Mixed iron & steel ..	4 12 6	4 15 0
Heavy cast iron ..		4 12 6
Good machinery for foundries		4 12 6
Cleveland—		
Heavy steel ..		4 15 0
Steel turnings ..		3 8 9
Cast-iron borings		3 8 9
Heavy forge ..		5 10 0
Bushelled scrap ..		5 0 0
Cast-iron scrap ..		5 2 6
Lancashire—		
Cast-iron scrap ..		4 15 0
Heavy wrought ..		5 5 0
Steel turnings ..		3 12 6

London — Merchants' buying prices delivered yard.

Copper (clean) ..	66	0	0
Brass (clean) ..	38	0	0
Lead (less usual draft)	23	10	0
Tea lead	21	10	0
Zinc	23	10	0
New aluminium cuttings	70	0	0
Braziery copper	56	0	0
Gun metal	50	0	0
Hollow pewter ..	170	0	0
Shaped black pewter	90	0	0

PIG-IRON.

N. E. Coast—

Foundry No. 1 ..	130/-
Foundry No. 3 ..	125/-
Forge No. 4	117/6
Mottled	—
Hematite No. 1 ..	123/6
Hematite M/Nos. ..	122/6

Midlands—

Staffs. common ..	—
,, part-mine forge	—
,, ,, foundry	—
,, Cold blast, ord.	190/-
,, ,, roll iron	200/-
,, basic ..	—
Northants forge .	100/-
,, foundry No 3	110/-
,, basic	115/-
Derbyshire forge	107/6
,, foundry No. 3	115/-
,, basic	115/-

Scotland—

Foundry No. 1 ..	125/-
,, No. 3 ..	120/-
Hematite M/Nos. ..	127/6

Sheffield (d/d district)—

Derby forge	111/-
,, foundry No. 3	116/-
Lincs. forge	110/-
,, foundry No. 3	115/-
,, basic	—
E.C. hematite ..	132/9
W.C. hematite ..	137/6

All d/d in the district.

Lancashire (d/d eq. Man.) —

Derby forge	—
,, foundry No. 3	128/6
Northants foundry No. 3	—
Cleveland foundry No. 3	—
Staffs. foundry No. 3	—
Lincs. forge	—
,, foundry No. 3	—
Dalzell, No. 3	137/-
Summerlee, No. 3 ..	137/-
Glengarnock, No. 3	137/-
Gartsherrie, No. 3 ..	137/-
Monkland, No. 3 ..	137/-

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.
Bars (cr.)	£12 to 12	10	0
Angles	12	5	0
Tees to 3 united ins.	12	10	0
Nut and bolt ..	11	15	0
Hoops	15	0	0
Marked bars (Staffs.)	14	10	0
Gas strip	13	0	0
Bolts and nuts, ⅜ in. × 4 in. ..	20	10	0
Steel—			
Ship plates	10	10	0
Boiler plates ..	14	0	0
Chequer plates ..	11	5	0
Angles	10	0	0
Tees	11	0	0
Channels	10	10	0
Joists	10	0	0
Rounds & squares 3 in. to 5½ in. ..	12	5	0
Rounds under 3 in. to ⅜ in. ..	12	0	0
Flats, over 5 in. wide and up ..	12	10	0
Flats, 5 in. to 1¼ in.	11	15	0
Rails, heavy ..	10	10	0
Fishplates	14	10	0
Hoops (Staffs.) ..	13	0	0
Black sheets, 24 g.	14	12	6
Galv. cor. sheets, 24 g.	19	10	0
Galv. fencing wire. 8 g. plain	18	5	0
Rivets, ¾ in. dia.	14	15	0
Billets, soft	10	0	0
Billets, hard	10	15	0
Sheet bars	£9/11/6 to 9	15	0
Tin bars	10	0	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 4
Sheet	1 4½
Wire	1 5½
Rods	1 3½
Tubes	1 7
Castings	1 2

Delivery 3 cwt. free to any town.

10% phosphor copper, £40 above price of B.S.

15% phosphor copper, £50 above price of B.S.

Phosphor tin (5%), £30 above price of English ingots.

Charles Clifford & Son, Limited, Birmingham.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/4 to 1/10
To 18 in. wide	1/4½ to 1/10½
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6½ to 2/0½
Ingots for spoons and forks ..	9d. to 1/3
Ingots rolled to spoon size ..	1/- to 1/6
Wire round—	
3/0 to 10 G...	1/6½ to 2/1½

with extras according to gauge

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	33.14
No. 2 foundry, Valley	31.00
No. 2 foundry, Birm...	27.00
Basic	32.77
Bessemer	32.77
Malleable	32.77
Grey forge	32.27
Ferro-manganese 80% delivered	125.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y, at mill	43.00
Bess. billets	45.00
O.-h. billets	45.00
O.-h. sheet bars ..	47.50
Wire rods	50.00
	Cents.
Iron bars, Phila. ..	2.82
Steel bars	2.50
Tank plates	2.50
Beams, etc.	2.50
Skelp, grooved steel ..	2.35
Skelp, sheared steel ..	2.35
Steel hoops	3.30
Sheets, black, No. 28	4.00
Sheets, galv., No. 28 ..	5.25
Sheets, blue an'l'd, 9&10	3.25
Wire nails	2.90
Plain wire	2.65
Barbed wire, galv. ..	3.70
Tinplate, 100-lb. box	$6.00

COKE (at ovens).

Welsh foundry ..40/- to 45/-
,, furnace ..30/- to 35/-
Durham & North. fdy... 47/6
,, furnace 39/-
Other Districts, foundry 47/6
,, furnace .. 37/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C.Cokes,	20×14, box	25/9
,,	28×20, ,,	51/6
,,	20×10, ,,	38/3
,,	18¾×14, ,,	26/9
C.W.	20×14, ,,	24/3
,,	28×20, ,,	48/6
,,	20×10, ,,	33/3
,,	18¾×14, ,,	24/3
Terneplates	28×20, ,,	46/9

TUBES.

	Up to and incl. 6 in.	
Gas ..	..57½%	Tube prices are now free.
Water	..52½%	
Steam	..47½%	

SWEDISH IRON.

Bars, hammered basis sizes—Basis price £22 to £23

	£ s. d.
Rolled Ordinary—Assortment ..	17 5 0 to 17 15 0
Nail Rods—Square, round and flats ..	

Keg Steel nom. £38 to £40

Faggot Steel nom. £30 to £32

Blooms—Single welded .. £10 to £11

Billets—Single and double welded .. .. £13 to £14

Pig-iron—Grey, white or mottled £6 15 to £7 5 0

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£ s. d.	
April 18	73 10 0	inc. 5/-
„ 19	73 10 0	No change
„ 20	73 0 0	dec. 10/-
„ 23	72 17 6	„ 2/6
„ 24	72 5 0	dec. 12/6

Electrolytic Copper.

April 18	81 5 0	inc. 5/-
„ 19	81 5 0	No change
„ 20	81 0 0	dec. 5/-
„ 23	81 0 0	No change
„ 24	80 15 0	dec. 5/-

Standard Tin (cash).

April 18	209 5 0	dec. 50/-
„ 19	208 15 0	„ 10/-
„ 20	207 15 0	„ 20/-
„ 23	212 15 0	inc. 100/-
„ 24	215 15 0	„ 60/-

Tin (English ingots).

April 18	209 10 0	dec. 45/-
„ 19	209 0 0	„ 10/-
„ 20	208 0 0	„ 20/-
„ 23	213 0 0	inc. 100/-
„ 24	216 0 0	„ 60/-

Zinc Sheets (English).

April 18	43 0 0	No change
„ 19	43 0 0	„
„ 20	43 0 0	„
„ 23	43 0 0	„
„ 24	43 0 0	„

Spelter (ordinary).

April 18	33 17 6	dec. 15/3
„ 19	34 5 0	inc. 7/6
„ 20	34 0 0	dec. 5/-
„ 23	33 17 6	„ 2/6
„ 24	33 12 6	„ 5/-

Lead (English).

April 18	27 15 0	dec. 5/-
„ 19	27 15 0	No change
„ 20	27 10 0	dec. 5/-
„ 23	27 5 0	„ 5/-
„ 24	27 10 0	inc. 5/-

AVERAGE MONTHLY PRICES OF EAST COAST HEMATITE MIXED NUMBERS F.O.T.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Yearly Average.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1915	.. 83 11	.. 88 6	.. 94 8	..107 0	..102 6	..101 3	.. 98 9	.. 98 7½	.. 96 6	..104 0	..124 1	..130 0	..106 11½
1916	..133 9	..140 0	..136 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..128 1½
1917	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6
1918	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6
1919	..122 6	..122 6	..122 6	..122 6	..179 2	..190 0	..197 6	..200 0	..200 0	..200 0	..200 0	..200 0	..171 4
1920	..220 0	..220 0	..240 0	..260 0	..260 0	..260 0	..260 0	..260 0	..260 0	..260 0	..260 0	..260 0	..251 8
1921	..240 0	..220 0	..180 0	..180 0	..180 0	..160 0	..160 0	..137 0	..127 6	..117 6	..104 6	..162 2	
1922	.. 97 6	.. 91 7½	..100 0	.. 98 6	.. 97 1½	.. 94 7	.. 93 6	.. 90 9	.. 89 7	.. 91 10½	.. 93 0	.. 93 2	.. 94 5½

AVERAGE PRICES OF STEEL RAILS.

Year.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Yearly Average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1908	.. 6 2 6	.. 6 0 0	.. 6 0 0	.. 5 15 6	.. 5 15 0	.. 5 15 0	.. 5 15 0	.. 5 15 0	.. 5 15 0	.. 5 15 0	.. 5 15 0	.. 5 10 0	.. 5 16 3
1909	.. 5 5 0	.. 5 5 0	.. 5 5 0	.. 5 0 0	.. 5 5 0	.. 5 5 0	.. 5 5 0	.. 5 5 0	.. 5 5 0	.. 5 5 0	.. 5 5 0	.. 5 5 0	.. 5 5 0
1910	.. 5 5 0	.. 5 7 6	.. 5 7 6	.. 5 7 6	.. 5 10 0	.. 5 10 0	.. 5 10 0	.. 5 10 0	.. 5 10 0	.. 5 10 0	.. 5 10 0	.. 5 10 0	.. 5 8 11½
1911	.. 5 15 0	.. 5 15 0	.. 5 15 0	.. 5 12 6	.. 5 12 6	.. 5 12 6	.. 5 12 6	.. 5 12 6	.. 5 12 6	.. 5 12 6	.. 5 12 6	.. 5 12 6	.. 5 13 1½
1912	.. 5 13 1	.. 5 15 0	.. 5 15 7	.. 6 1 6	.. 6 6 3	.. 6 7 6	.. 6 8 0	.. 6 11 3	.. 6 12 6	.. 6 12 6	.. 6 13 9	.. 6 4 4	
1913	.. 6 15 0	.. 6 14 4½	.. 6 12 6	.. 6 12 6	.. 6 12 6	.. 6 12 6	.. 6 12 6	.. 6 12 6	.. 6 10 0	.. 6 10 0	.. 6 10 0	.. 6 10 0	.. 6 12 0
1914	.. 6 10 0	.. 6 10 0	.. 6 6 3	.. 6 0 0	.. 6 0 0	.. 6 0 0	.. 5 14 0	.. 6 2 6	.. 6 13 9	.. 6 12 0	.. 6 7 6	.. 6 7 6	.. 6 5 3½
1915	.. 6 10 6	.. 6 17 6	.. 7 5 0	.. 7 12 6	.. 7 12 6	.. 7 17 6	.. 8 17 6	.. 9 2 6	.. 9 2 6	.. 9 2 6	.. 9 7 6	.. 10 10 6	.. 8 6 6½
1916	..10 19 4	..11 0 0	..11 0 0	..10 18 9	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 9 10
1917	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6
1918	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6	..10 17 6
1919	..10 17 6	..13 7 6	..13 7 6	..13 7 6	..15 0 0	..15 10 0	..16 0 0	..16 10 0	..16 10 0	..16 10 0	..16 10 0	..17 5 0	..14 12 11
1920	..18 15 0	..19 5 0	..20 7 6	..22 0 0	..23 0 0	..23 0 0	..24 0 0	..25 0 0	..25 0 0	..25 0 0	..25 0 0	..25 0 0	..22 18 11½
1921	..23 5 0	..20 4 0	..18 0 0	..17 0 0	..15 0 0	..15 0 0	..14 0 0	..14 0 0	..14 0 0	..11 12 6	..10 10 0	..10 0 0	..15 4 3
1922	.. 9 10 0	.. 9 10 0	.. 9 10 0	.. 9 10 0	.. 9 10 0	.. 9 10 0	.. 9 10 0	.. 9 0 0	.. 8 15 0	.. 8 15 0	.. 8 15 0	.. 8 15 0	.. 9 4 2

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PATENTS.

INVENTORS Advice, Handbook and Consultations Free. KING'S PATENT AGENCY, LIMITED, Director, B. T. King, Regd. Patent Agent, 146a, Queen Victoria Street, London; 36 years' references.

PATENTS AND DESIGNS ACTS, 1907 AND 1919.

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